Essays on the Economics of Fertility

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Abstract

This thesis includes three topics: (a) the effects of childbirth subsidy policies on the number of births in South Korea, (b) how a slowdown in retirement affects fertility rates among young adults through the labor market, and (c) how underemployment (i.e., overeducation) affects marriage and childbirth among young adults.

In the first essay, I analyzed the effects of three types of childbirth subsidy policies on the number of births in South Korea using collected data, where the total fertility rate (TFR) has repeatedly hit record lows over the past few decades. Because these policies are a typical example of staggered treatment timing, I adopted interaction-weighted (IW) estimators to return values that would permit interpretation of causal relationships. The results show that the subsidies for families who produced their first (second) child increased the number of first (second) children by 3.4% (2.8%) to 5.0% (11.6%). I found a consistently positive impact of the first and second child policies when separately analyzing data from urban and rural areas. However, based on sensitivity analysis, for which I modified the original IW estimates by using observed pre-existing trends as possible post-trends, the cash-based subsidies for first (second) children positively related to the number of first (second) children only in urban (rural) areas, suggesting heterogeneous effects of the same policies in urban and rural areas. Based on IW estimates or sensitivity analysis, no evidence emerged that providing grants for third or subsequent births contributed to an increase in third or subsequent children.

The aim of the second essay was to examine the impact of an increase in the retirement age on the fertility of young adults based on their labor market outcomes. I investigated whether delayed retirement among the elderly beyond FRA (Full Retirement Age) deteriorated the quantity and quality of employment, and eventually the childbirth, of young adults. I found that a higher number of older workers decreased full-time employment and increased part-time employment for economic reasons among young adults aged 20–29. However, workers aged 30–39 remained unaffected. Second, I confirmed the relationship between childbirth and economic conditions: full-time employment positively related to fertility, and part-time employment for economic reasons and unemployment negatively related to fertility. Finally, I found two pathways through which a growing elderly workforce compromised fertility among young adults: (a) lowering the number of young adults aged 20–24 who were full-time workers and (b) raising the number of young adults aged 20–24 and 25–29 who were part-time workers. In particular, the negative impact on fertility due to delayed retirement was concentrated in married individuals aged 20–24 years.

In the third essay, I explored the effect of underemployment – a phenomenon in which 4-year college graduates gain employment in a place that does not require that degree – on marriage and childbirth using the NLSY97. To help explain the link between underemployment and marriage and childbirth, I additionally investigated the factors related to initial underemployment and the effect of underemployment on future labor market outcomes. First, I found that being underemployed at the start of a career highly related to grades and major. Second, I found no evidence that underemployment prevented marriage and childbirth in the short term, both in cross-sectional and panel analyses. Third, through a hazard model analysis, I confirmed that underemployment persistently affected future labor market outcomes for both men and women and that the effect was stronger for men. I also found that, at least for women, underemployment at the beginning of a career negatively related to having a first child. Fourth, with a different measurement method to judge underemployment, I found that underemployed men at a starting point in their career were more likely to remain persistently underemployed but that being underemployed at the start did not relate to marriage or childbirth for men and women.

JEL Codes: J13, J21, K36

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Chapter 1

The Effects of Childbirth Subsidies on Number of Births in South Korea

1.1 Introduction

Low birth rate has long been a social problem in OECD countries, 34 out of 36 of which had a total fertility rate[1] (TFR) of less than the population replacement rate of 2.1 in 2018. The low birth rate is not simply a matter of low fertility but gives rise to inequality and conflict between generations within the pay-as-you-go pension system. Furthermore, low birth rate translates directly to labor shortages in subsequent generations, potentially slowing economic growth. To deal with this issue, many countries (e.g., several Western European countries, Canada, Australia) with low birth rate have already implemented financial assistant programs, such as family allowances and pronatalist tax benefits, since the 1980s (Azmat and González, 2010; Drago et al., 2011; Kalwij, 2010; Milligan, 2005).

For South Korea (hereafter, Korea), which has mandatory health insurance and national pensions for all citizens, the issue of a severely low birth rate is inevitably more threatening than for other countries. Maintaining a constant population size is a crucial prerequisite to the stable and equitable operation of these health insurance and pension systems. However, since TFR in Korea fell below the population replacement rate of 2.1 in 1983, it has continued to decline, currently ranking near the bottom of the lowest fertility rates in the world. Furthermore, Korea hit the "population death cross" in 2020 for the first time ever, recording more deaths than births. The decreasing

[1] Total fertility rate (TFR) is the average number of children that would be born to a woman over her lifetime (aged 15 to 49).

number of births becomes more problematic in conjunction with an aging society. Korea's elderly support ratio was 21.7 in 2020 and could rise to 29.3 by 2025 and 38.2 by 2030 (Statistics Korea), calling for active and immediate actions against this demographic crisis.

In the meantime, Korea has made various efforts to encourage giving birth: maternity and parental leave system, payment of childbirth incentives, and support for treatment expenses for infertile couples. Subsidies for families with a new baby are the most typical; almost all local governments had implemented at least one type of childbirth subsidy policy by 2017. However, policymakers disagree with the effectiveness of these policies. In a 2006 interview, Hajin Jang, former minister of Gender Equality and Family, said that the childbirth subsidy policies implemented by local governments did not positively affect the number of births (Jeonnamilbo, 2006).

Even scholars have not reached a consensus on the effect of family income subsidy policies designed to encourage families to have more children. Previous findings about childbirth subsidies in Korea generally fall into two categories: (1) including all municipalities, childbirth subsidies have increased the number of births (Lee et al., 2012; Park and Song, 2014; Son, 2018) and (2) in specific regions (e.g., Seoul metropolitan city), policies have been ineffective in promoting childbirth (Kim and Cheon, 2016; Suk, 2011).

Findings about cash-based policies in countries other than Korea are also inconsistent. According to a series of studies conducted in 16 OECD countries,[2] Canada, Australia, and Spain, cash-based subsidies (e.g., family allowances, tax credits, and baby bonuses) positively affected the number of births (D'Addio and Marco, 2005; Azmat and González, 2010; Drago et al., 2011; Milligan, 2005). However, findings from studies about 16 Western European countries[3] and Australia indicate that cash support did not significantly impact birth rates (Kalwij, 2010; Parr and Guest, 2011).

Motivated by doubts about the effectiveness of the childbirth subsidy policies currently implemented in Korea, I examined whether these policies have induced people to have more children.

[2]Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, the United Kingdom, and the United States.

[3]Sweden, Norway, Finland, Denmark, Germany, Austria, Belgium, the Netherlands, Switzerland, the United Kingdom, Ireland, France, Portugal, Spain, Italy, and Greece.

Providing reliable policy effects is the first step towards fundamental changes in government-operated policies to address a growing population crisis.

I first collected data related to childbirth subsidy policies from 17 metropolitan and 228 local governments[4] during the period 2001–2017 by contacting each municipality through the "information disclosure system."[5] To determine policy effects, I first employed a standard difference-in-differences (DID) model, which is the most common method investigating policy effects, using regional variation in the introductions of childbirth subsidies. Next, I adopted interaction-weighted (IW) estimators (Sun and Abraham, 2021) to examine how policy effects changed over time. This new method is essentially similar to a standard event model. The difference is that IW estimators return coefficients that indicate causality, even in analyses involving multiple treatments. In recent years, several scholars have pointed out the risk of interpreting the results estimated by standard estimation methods (i.e., linear two-way fixed effect model or event study) commonly used for staggered setups such as policy intervention (Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021). In this context, IW estimators allowed me to avoid this issue and obtain reliable average treatment effects on the treated (ATTs) for Korea's childbirth subsidy policies, which feature staggered adoption.

Furthermore, I performed sensitivity analysis by constructing "honest" confidence sets for already estimated policy effects. Using the method proposed by Rambachan and Roth (2019) for building robust confidence intervals, I examined how the estimated IW coefficients changed when I accounted for possible post-differential trends. Conducting this analysis helped me avoid any violation of the parallel trend assumption because I confirmed significant pre-existing trends in the IW estimation results.

Results from standard DID analysis revealed that the number of second children increased by 5.4% in municipalities that provided subsidies for a second child. The subsidies for a first and a third or subsequent child did not motivate families to have those corresponding children. In the

[4]Korea consists of 17 metropolitan cities, comprising 228 municipalities (see Appendix, Figure 1.A1).

[5]Using this online information disclosure system, governments (local, metropolitan, and national) and public agencies must provide information requested by a citizen within a certain period if the requested information can be disclosed to the public.

IW analysis, I found that subsidies for a first (second) child increased the number of first (second) children over a period of four (nine) years and that the degree of increase varied from 3.4% (2.8%) to 5.0% (11.6%) during post-periods. However, even in the IW analysis, I did not find that subsidies for third or subsequent births increased the frequency of additional children. Moreover, the effects of each policy in the full sample followed the same pattern in urban and rural areas.

However, after adjusting the original IW coefficients using existing pre-trends, the modified policy effects were considerably different in magnitude and statistical significance, especially in the sub-group analysis. The results show that the childbirth subsidies for first children still increased the number of first children in the full sample. The only difference between the IW estimates and the modified IW estimates is that the latter indicated a greater impact of subsidies on first births, suggesting that the IW coefficients were underestimated. However, when I divided the sample into urban and rural areas, the results showed that families living in urban areas responded to birth incentives for a first child and that those living in rural areas did not.

For subsidies for a second child, when reflecting the existing pre-trends between the treatment and control groups, I found that the second child policy effects estimated to be positive significantly became smaller than the original IW estimates. In addition, the persistence of the policy effects was also less than the IW estimates, showing that the second child policy was an effective way to increase a second child for only four years following policy introduction. In the sub-group analysis, the estimated positive impact on second births in urban areas almost disappeared for all post-periods. In contrast, the childbirth subsidies for second children still increased the number of second children in rural areas. These results suggest that local governments might enhance the effectiveness of these policies by considering the TFR and demographic characteristics within certain areas, given that the average TFR in rural areas was slightly closer to two than in urban areas.

Still, I found that subsidies for third or subsequent births did not boost the number of additional children in sensitivity analysis. These results, combined with the fact that the subsidy for a third or subsequent child was about 3.5 times the amount for a first child and about 2.5 times the amount for a second child in 2017, suggest that policymakers need to reconsider which policy most effectively raises the total number of births.

The findings of this paper are important for two reasons. First, the findings provide a comprehensive understanding of the effects of childbirth subsidy policies in Korea based on rich data. The vast dataset enables tracking of changes in policy effect up to thirteen years after policy introduction. The dataset also permitted sub-group analysis and the identification of heterogeneous effects of the same policies in urban and rural areas. Most importantly, these results offer reliable evidence of causal effects because I controlled for emerging issues when analyzing the staggered introduction of policies suspected random assignment. Second, the findings complement previous research about the effects of cash-based childbirth subsidy policies by permitting additional policy evaluation. The apparent impact of childbirth incentives on the childbirth rate depends on the countries and periods analyzed. Based on the current case study of Korea, the findings support the conclusion that financial incentive programs can, to some extent, increase the motivation to have more children.

The remainder of the paper is organized as follows. Section 1.2 briefly summarizes the features of childbirth subsidy policies in Korea. Section 1.3 introduces the data, and Section 1.4 describes the methodology. Section 1.5 presents the tentative results obtained from the IW estimator, and Section 1.6 exhibits robust confidence sets that reflect possible post-differential trends in the treatment group. Section 1.7 discusses policy implications based on the results, and Section 1.8 summarizes the findings.

1.2 Childbirth Subsidy Policies in South Korea

1.2.1 TFR trends

Korea experienced a baby boom immediately after the Korean Armistice Agreement in 1953. In the late 1950s, the government determined that Korea's explosive population growth rate of 2.9% would hinder economic growth. Therefore, after TFR reached 6.0 in 1960, the government implemented a strict birth control policy in 1961 to maximize economic development (The Ministry of

Health and Welfare).

Over the next 20 years, TFR in Korea rapidly declined, making Korea one of the low birth rate countries with TFR below the population replacement rate of 2.1 in 1983. In the 1990s, the demographic problem that Korea faced was no longer rapid population growth due to a high birth rate but a slowing population growth rate due to a low birth rate. To cope with the low birth rate, the government abolished the existing birth control policy in 1996. However, TFR continued to decrease. In 2001, TFR dropped below 1.3, and Korea became an ultra-low birth rate country.[6] Given that the number of fertile women has continually decreased since 2002, the number of births during that time has decreased more than TFR has. "Education fever" (Anderson and Kohler, 2013), unequal division of domestic chores by gender,[7] the low take-up rate of maternity and parental leave (Park, 2020),[8] and avoidance of marriage due to financial hardship[9] are among the factors contributing to the decline in fertility rate.

1.2.2 Childbirth subsidy policies

In response to severe declines in birthrate, some municipalities attended to childbirth promotion policies ahead of the national government.[10] Since Jeollanam-do[11] and Gunwi-gun began subsi-

[6]see Appendix, Figure 1.A2

[7]According to "2019 Korea's Social Indicators" released by Statistics Korea, only 20.2% of husbands and 19.5% of wives thought they were sharing household chores equally.

[8]Korea currently guarantees 90 days of paid maternity leave and 12 months of paid parental leave by law. However, according to a survey conducted by the National Human Rights Commission of the Republic of Korea, although 94.4% of women and 93.8% of men recognized the existence of maternity leave, the actual use of these leaves tends to be low (51% of women and 24% of men), in part due to concerns about discrimination related to placement, promotion, compensation, and evaluation.

[9]Because out-of-wedlock birthrates in Korea are extremely low, a high marriage rate is a prerequisite for a high birthrate. According to the results of a survey conducted by the Seoul Metropolitan Government, as reasons for not getting married, 35.3% of respondents reported that weddings cost too much, and 40.2% answered that they did not have a job or enough income to maintain a marriage.

[10]The national government enacted "The Framework Act on Low Birthrate and Aging Society" in 2005 in response to the declining birthrate and aging population. Additionally, between 2006 and 2010, the government enacted "The First Plan for Aging Society and Population" with the goal of establishing a fundamental basis for addressing the two trends. Having completed the second plan (2011–2015) and the third plan (2016–2020), Korea is currently operating a fourth plan (2021–2025).

[11]Korea has eight metropolitan cities (i.e., Seoul, Busan, Daegu, Incheon, Gwanju, Daejeon, Ulsan, and Sejong) and nine provinces (i.e., Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do, Gyeongsangnam-do, and Jeju-do). These cities and provinces have their own city-county-district units of authority to enact their own ordinances, which must not violate any ordinances of the higher

dizing families with a new baby to encourage childbirth in 2001, the number of municipalities with similar policies has gradually increased over the past 20 years. One reason for the spread of such policy introduction is that local governments might have been experiencing a critical low birth rate. Another possibility is the commitment of local governments to meet the national goal of encouraging childbirth, marked in 2005[12] by "The Framework Act on Low birthrate and Aging Society." Yet another reason is the possibility of policy diffusion. Bae (2010) found that the introduction of childbirth subsidy policies among 50 local governments in the capital area closely related to whether neighboring local governments introduced similar policies. Although the scope of subsidy payments varies from region to region, 225 out of 228 local governments had implemented at least one of the childbirth subsidy policies as of 2017, firmly establishing a pro-natal initiative in Korea.

The childbirth subsidy programs currently implemented in Korea differ across municipalities because local governments have discretion over their own ordinances. As long as their policies do not violate provincial or national law, local governments have the power to enforce any policy within their budget capacity. As a result, the year of introduction and subsidy amounts differ from region to region. In particular, the birth orders to which childbirth subsidies apply vary across local governments. Therefore, I divided the childbirth subsidy policies into three categories: (1) first births (i.e., first child policy), (2) second births (i.e., second child policy), and (3) third or subsequent births (i.e., third child policy).

In some cases, families who reside in a municipality might be part of two subsidy programs because both a metropolitan government and a local government under its administration can manage similar programs to promote childbirth. Indeed, 12 out of 17 metropolitan administrations were implementing childbirth subsidies as of 2017. In these cases, the higher-level government pays its share as determined through mutual consultation with the lower-level governments. The two governments then provide the total subsidy promised by both ordinances to the family who has had a new baby. To receive subsidies from multiple levels of government, a family with a newborn only

government to which they belong.

[12] See Appendix, Figure 1.A3.

needs to apply within the local government, for the two programs practically act as one program for an eligible family. Therefore, in the current study, I defined a childbirth subsidy as the sum of temporary and split cash support paid to a family with a newborn, regardless of policy name[13] or source of funds.

The childbirth subsidy policies in Korea have two main features. First, they are a typical example of staggered treatment with multiple cohorts. In this study, I defined a cohort as a group of municipalities that introduced the same program in the same year. Because local governments are in charge of their own policy enforcement, the timing of policy introduction is likely to differ. Over the period 2001–2017, a group of municipalities (i.e., a cohort) sequentially introduced a policy every year except 2002 and 2003. The number of regions in a cohort ranges from one to fifty-one. Such a staggered policy adoption involving multiple cohorts might lead to heterogeneous policy effects across cohorts. I discuss this issue further in the methodology section.

Across the cohort as a whole,[14] the lower the average number of births during the years before policy introduction, the earlier that introduction tended to be. Furthermore, municipalities with fewer births before policy implementation tended to higher subsidies after policy enforcement.

These characteristics by cohorts raised two issues related to methodology and division of the sample. First, the positive relationship between the average number of births before policy introduction and the timing of policy introduction suggests that the impact of policy intervention might differ across cohorts; after all, local governments with lower birthrate were more likely to introduce a policy earlier than local governments where low birthrate was less serious. Furthermore, the red horizontal line in the first and second graphs in Panel B of Figure A5 represents the average decrease in births in municipalities that had not introduced childbirth subsidies by 2017 (i.e., control group). This average was relatively lower than the average in regions that had introduced childbirth subsidies (i.e., treatment group). This difference raised the possibility of violating the parallel trend assumption, which is crucial to DID analysis. The heterogeneity across cohorts and

[13] The subsidies also have different names across regions, such as "childbirth congratulatory money," "childbirth incentives," and "support for newborn childcare."

[14] See Appendix, Figure 1.A5

the possibility of this violation required a different empirical strategy from a standard method. Combined with the issue of staggered multiple treatments, this difference presented a challenge in producing actual policy effects using DID analysis. I discuss these issues further in the methodology section.

Moreover, the negative relationship between the average number of births during the pre-periods and the average subsidies during the post-periods suggests a difference in policy effects between urban and rural areas. Rural areas tended to offer relatively higher subsidies for a new baby than urban areas. Indeed, local governments in rural areas provided about three times as much cash for a second or subsequent child as local governments in urban areas did in 2017. Based on this observation, I conducted both full sample and sub-group (i.e., urban and rural areas) analysis.

Another prominent feature is that the primary goal of childbirth subsidy policies in Korea seems to be to increase the intensive margin of fertility (i.e., increasing the number of higher-order births in families that already have children) rather than increasing the extensive margin (i.e., increasing the number of first births in childless families). This policy focus of local governments is clear through the order of policy introduction and subsidy amounts for different birth orders.

Although the scope of coverage based on birth order[15] differs across municipalities, local governments that introduced a policy tended to start by providing subsidies for higher birth orders. In other words, if a municipality implemented the second child policy, it implemented the third child policy at the same time even though it might not have yet introduced the first child policy. Similarly, if a municipality implemented the first child policy, it has already implemented both the second and third child policies. Put differently, the set of municipalities providing subsidies for only third or subsequent births includes the set of municipalities providing subsidies for second and subsequent births. And the latter set also includes local governments with all three types of childbirth subsidy policies.

The stance of local governments also gained clarity through subsidy amounts. The subsidies for second or subsequent births were larger than first births each year. Furthermore, even though

[15] In the context of childbirth subsidy payment, birth order refers to the sequence of newborns in a family, not the overall number of times the mother has given birth in her lifetime.

subsidies for all new babies increased over time, the increase for second or subsequent births was higher than first births, suggesting that policymakers focused on providing benefits to families having a second or subsequent child, especially for a third or subsequent child. The average subsidy amount for first children increased from 210,000 won ($188) in 2001 to 1,030,000 won ($907) in 2017.[16] For second births, the amount increased from 210,000 won ($188) to 1,430,000 won ($1,269). The increase in benefit for third or subsequent births was much greater,[17] from 780,000 won ($686) to 3,630,000 won ($3,207). That TFR in Korea is now below one merits discussion about whether these policy goals are best for raising the total number of births in Korea.

1.3 Data

1.3.1 Data on childbirth subsidy policies

Because childbirth subsidy policies operate within local governments, the central government does not collect or manage this kind of data. Hence, to analyze the effects of childbirth subsidy policies on the number of births, I first requested information about childbirth subsidies directly from 228 local governments and 17 metropolitan governments through an "information disclosure system"

[16] I used CPI to adjust the subsidy amounts (base year of 2015). I calculated these amounts using the exchange rate in 2017 provided by the Bank of Korea, which is $1 = 1,130.84 won (2017 being the final year of my dataset). This exchange rate determines all U.S. dollar conversions in the current study unless otherwise noted.

[17] The childbirth subsidy amounts for first and second births are identical to the data obtained from local governments. However, I recalculated the amounts for the third or subsequent births using data for the number of births at the metropolitan level and data for the childbirth subsidies at the local level. I did so because information from municipalities contained childbirth subsidy amounts for the third, fourth, and fifth or subsequent births. However, data about birth order at the municipal level only contained the number of first, second, and third or subsequent births. Therefore, I calculated the weights for the third, fourth, and fifth or subsequent births using the data from metropolitan governments and then multiplied these weights by the childbirth subsidy amounts for the third, fourth, and fifth or subsequent births provided by local governments, respectively. The sum of these amounts represent childbirth subsidies for the third or subsequent births, according to following formula:

$$\text{childbirth subsidies for the third birth}_{ij} \times \frac{\text{the number of third births}_j}{\text{the number of third or subsequent births}_j}$$
$$+ \ \text{childbirth subsidies for the forth birth}_{ij} \times \frac{\text{the number of fourth births}_j}{\text{the number of third or subsequent births}_j}$$
$$+ \ \text{childbirth subsidies for the fifth birth}_{ij} \times \frac{\text{the number of fifth or subsequent births}_j}{\text{the number of third or subsequent births}_j},$$

where i represents 228 local governments and j represents 17 metropolitan governments.

provided by the Ministry of the Interior and Safety.[18] To ensure the accuracy of the data, once I received the materials, I double-checked the data by comparing them to the ordinances of local and metropolitan governments. Finally, I confirmed the data by speaking to the person in charge of the local government when a discrepancy appeared between the data I received and the information in the ordinances. Data collected includes information about the year of policy introduction, subsidy amounts, payment methods, and coverage from 2001 to 2017.

1.3.2 Other data

The crude marriage rate, the crude divorce rate, the number of births by birth order, and the number of women aged 15 to 49 came from the "Population Trend Survey" of Statistics Korea. Income per capita came from the "Local Income" record of Statistics Korea, and the unemployment rate among people aged 30 to 59 came from the "Economically Active Population Survey" of Statistics Korea.

1.4 Methodology

1.4.1 Standard difference-in-differences

To examine the effects of childbirth subsidies on the number of births, I first used a standard DID method taking advantage of the variation in policy introduction across municipalities. Because Korea currently offers three types of childbirth incentives, I regressed the following equation for the three programs separately:

$$y_{it} = \beta_1 policy_{it} + X_{it}\beta_2 + \zeta_i + \tau_t + \varepsilon_{it} \tag{1.1}$$

[18] Many researchers have extracted subsidy amounts for childbirth through relevant municipal ordinances or "the local government's population casebook." However, Park and Song (2014) pointed out that the subsidy amounts indicated in municipal ordinances and the casebook differ from the actual amounts that municipalities gave their citizens. Therefore, I collected data on childbirth subsidy policies in person.

where i represents each municipality and t represents the calendar year; thus, ζ_i and τ_t are coefficients of region (i.e., municipality) and year fixed effects, respectively. The dependent variable, y_{it}, is the log-transformation of the number of first (second, third+) children born in municipality i and year t. $policy_{it}$ is a dummy variable indicating whether municipality i introduced a first (second, third) child policy in year t. X_{it} represents a vector of control variables, including municipality-level controls (e.g., the crude marriage rate, the crude divorce rate, and the number of women aged 15 to 49), and metropolitan-level controls (e.g., the unemployment rate among people aged 30 to 59 and income per capita). Due to the time lag between giving birth and the decision to have a child, I used lagged variables for all control variables. For the crude marriage rate, I used the $t-1$, $t-2$, and $t-3$ lag variables as control variables to analyze the effect of childbirth subsidy policies on second or subsequent births.

I removed all municipalities that had already launched subsidy policies before 2003 from the sample to satisfy the requirements DID analysis. Furthermore, I dropped all cases in which administrative districts were integrated or newly established or in which local governments stopped and restarted policies during the period in question. I finally used 190 (193, 198) local government samples out of 228 municipalities to identify childbirth subsidy effects on first (second, third+) children.

Whereas equation (1.1) examines whether each policy increased the number of births in the birth order targeted by the policy, equation (1.2) examines how each policy affected the total number of births:

$$\begin{aligned} log(totalbirths)_{it} = \beta_1 firstpolicy_{it} + \beta_2 secondpolicy_{it} + \beta_3 thirdpolicy_{it} \\ + X_{it}\beta_4 + \zeta_i + \tau_t + \varepsilon_{it} \end{aligned} \tag{1.2}$$

$firstpolicy_{it}$ $(secondpolicy_{it}, thirdpolicy_{it})$ is a dummy variable indicating whether municipality i introduced a first (second, third) child policy in year t. Thus, the coefficients of interest are β_1, β_2, and β_3 in this equation. Local governments with the third child policy include all of the local governments with the second child policy. Also, the set of local governments with the second child policy includes all of the local governments with the first child policy. Thus, β_3 refers to the effect of the third child policy on the total number of births. Similarly, β_2 (β_1) indicates the effects of the second (first) child policy on the total number of births.

1.4.2 Continuous difference-in-differences

Because the childbirth subsidy amounts differed across municipalities, I estimated the effect on the number of births using those differences through the continuous DID method from Acemoglu et al. (2004).

$$y_{it} = \beta_1 policy_{it} + \beta_2 policy_{it} * subsidy_{it} + X_{it}\beta_3 + \zeta_i + \tau_t + \varepsilon_{it} \tag{1.3}$$

where $subsidy_{it}$ represents the subsidy amount in municipality i and year t. Because $policy_{it}$ indicates a policy introduction, the sum of β_1 and β_2 is the policy effect of interest. All other subscripts and variables are exactly the same as equation (1.1). I regressed this specification for the three policies independently.

1.4.3 Interaction-weighted (IW) estimators

An important feature of the childbirth subsidy policies in Korea is that the year of policy introduction tends to differ by region. Meanwhile, regardless of staggered or non-staggered treatment setup, extended DID (i.e., event study) is generally good for estimating the dynamic average treatment effects on the treated (ATTs) using variation in the timing of policy introduction. Recently, however, findings from some econometric studies indicate that standard estimation methods (i.e., linear two-way fixed effect model or event study) commonly used in staggered setups no longer guarantee that returned coefficients are interpretable as causal effects (Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021).

Sun and Abraham (2021) proposed interaction-weighted (IW) estimators as an alternative method for estimating dynamic ATTs by showing that estimated coefficients are interpretable as causal effects even under heterogeneous treatment effects across cohorts. As shown in Tables

1.B6–1.B8, the average number of births before and after policy introduction and the average subsidies paid for each cohort were considerably heterogeneous across all three policies. Thus, I adopted IW estimators to obtain causal effects of policy intervention even with multiple treatment times and multiple heterogeneous cohorts. As with other DID-based models, this alternative estimator also requires the following two identifying assumptions: (1) parallel trends in baseline outcome and (2) no anticipatory behavior.

Cohort-specific average treatment effects on the treated (CATTs)

To obtain IW estimates, I first found CATTs using an interactive model saturated in relative time[19] and cohort indicators (i.e., full model). Equation (1.4) specifies this full model.

$$
\begin{aligned}
y_{it} = & \sum_{l=-14, l\neq -1}^{0} \delta_{c2017,l}\, policy_{c2017,l} + \sum_{l=-13, l\neq -1}^{1} \delta_{c2016,l}\, policy_{c2016,l} \\
& + \cdots + \sum_{l=-2, l\neq -1}^{12} \delta_{c2005,l}\, policy_{c2005,l} + \sum_{l\neq -1, l=0}^{13} \delta_{c2004,l}\, policy_{c2004,l} \\
& + X_{it}\beta_1 + \zeta_i + \tau_t + \varepsilon_{it}
\end{aligned} \tag{1.4}
$$

where l represents the time relative to the year of policy introduction (i.e., relative time). Because the sample period is 2003–2017 and local governments adopted at least one of the policies between 2004 and 2017, the window of relative time was -14 to 13. Subscript C_{2016} represents cohort 2016, the group of municipalities adopting a policy in 2016. A variable $policy_{c2016}$ indicates whether cohort 2016 started providing subsidies. Thus, $\delta_{c2016,l}$[20] is the coefficient of an indicator for time l relative to policy introduction by cohort 2016, which is the DID estimate for cohort 2016 in a given time l. Because the sample period is 2003–2017, relative time l for cohort 2016 ranged from -13 to 1. In the same manner, $\delta_{c2004,l}$ is the DID estimate of cohort 2004 in a given relative time l, ranging from -1 to 13. Because cohort 2004 introduced a policy in 2004, they only had one

[19] I calculated relative time by subtracting the year of policy introduction from the calendar year included in the sample. Thus, negative relative time indicates pre-period (i.e., the period before policy introduction). Similarly, positive relative time indicates post-period. Relative time l = 0 indicates the year the policy started.

[20] For example, $\hat{\delta}_{c2016,-4} = (\bar{y}_{D=1,t=2012} - \bar{y}_{D=1,t=2015}) - (\bar{y}_{D=0,t=2012} - \bar{y}_{D=0,t=2015})$.

pre-period, denoted by a relative time of -1 and 14 post-periods. For example, the first full model yielded 196 CATTs, based on 14 cohorts (2004–2017) and 14 relative times for each cohort (except for the reference relative time). Among them, 91 CATTs were pre-period coefficients (i.e., $\delta_{cohort,l}$ for $l <$ -1); the remainder were post-period coefficients (i.e., $\delta_{cohort,l}$ for $l >$ -1).

In the current study, I used relative time -1 as a reference year. By doing so, I eliminated any anticipatory effect that might have existed. In the case of a childbirth subsidy policy, unlike other policies, the reference year would seem to be relative time 0, considering the time lag of about one year between actual birth and the decision to have a child. Given that almost all local governments announced policy implementation ahead of the effective date, especially because they offered financial incentives to engage in certain behaviors, these plans might have generated an anticipatory effect. If people responded to a policy earlier than it took effect, this anticipatory effect would be a positive coefficient value for relative time 0 even considering the time lag of childbirth. Accordingly, setting relative time 0 as the reference year might have underestimated policy effects. However, designating the reference year to -1 solves this problem. The combination of early announcement and time lag in childbirth effectively canceled any anticipatory effect, creating an environment in which policy effect would begin in the first year of plan enforcement, satisfying one of the identifying assumptions. I discuss the other assumption (i.e., parallel trends in baseline outcome) in Section 1.6.

Equation (1.5) is the generalized form of equation (1.4):

$$y_{it} = B_{it}^T \delta + X_{it}\beta_1 + \zeta_i + \tau_t + \varepsilon_{it} \tag{1.5}$$

where B_{it} is a column vector collecting $1\{E_i = e\} \cdot D_{it}^l$ for the year of policy introduction $2004 \leq e \leq 2017$ and relative time 2003 - $e \leq l \leq$ 2017 - e for each cohort e. δ is a column vector consisting of $\hat{\delta}_{e,l}$ on $1\{E_i = e\} \cdot D_{it}^l$ (Sun and Abraham, 2021).

Interaction-weighted (IW) estimators

After estimating CATTs using the full model, I calculated IW estimates. The IW estimator for each relative time is a weighted average of estimates $\hat{\delta}_{e,l}$ in which the weight is equal to the share of each cohort in a given relative time l. That is, IW estimates for the first and second models are calculated as follows.[21] This estimator easily applies to the third model after adjusting the sample period.

$$\hat{\vartheta}_l := \sum_{e=2003-l}^{2017} \frac{N_e}{\sum_{e=2003-l}^{2017} N_e} \hat{\delta}_{e,l} \text{ for } l < -1$$

$$\hat{\vartheta}_l := \sum_{e=2004}^{2017-l} \frac{N_e}{\sum_{e=2004}^{2017-l} N_e} \hat{\delta}_{e,l} \text{ for } l \geq 0$$

This weighted average value (i.e., IW estimate or a coefficient for each relative time) can indicate a causal effect even though each cohort has a different treatment effect in a given relative time $l \geq 0$, assuming parallel trends and no anticipatory behavior.

1.5 Empirical Results

1.5.1 Basic results

Table 1.1 displays the effects of childbirth subsidy policies on births estimated by standard DID analysis.[22] Panels A and C represent the effect of the first and third child policies on corresponding

[21]For example, because only three cohorts, 2015–2017, are in relative time -12, the following formulae calculate IW coefficients of relative time -12, $\hat{\vartheta}_{-12}$:

$$\hat{\vartheta}_{-12} = \frac{N_{e=2015}}{N_{e=2015} + N_{e=2016} + N_{e=2017}} \times \hat{\delta}_{2015,-12} + \frac{N_{e=2016}}{N_{e=2015} + N_{e=2016} + N_{e=2017}} \times \hat{\delta}_{2016,-12} + \frac{N_{e=2017}}{N_{e=2015} + N_{e=2016} + N_{e=2017}} \times \hat{\delta}_{2017,-12}$$

[22]I tested the parallel-trend assumption (i.e., Test the hypothesis that leads are equal to zero.). With 3 leads, the parallel-trend assumption was not passed for the third child policy in rural sample at the significant level of .90. With

births: implementation of the first (third) child policy did not increase the number of first (third or subsequent) children. These results are consistent when dividing the sample into urban and rural areas.

Table 1.1: Effects of childbirth subsidy policies on the number of births

	Full sample	Sub-sample	
		Urban	Rural
Panel A.The effects of subsidies for the first child on first births			
First child policy	0.024	0.027	0.035
	(0.015)	(0.017)	(0.022)
Number of regions	190	128	62
N	2,850	1,920	930
Panel B.The effects of subsidies for the second child on second births			
Second child policy	0.054***	0.045***	0.068***
	(0.014)	(0.014)	(0.025)
Number of regions	193	129	64
N	2,895	1,935	960
Panel C.The effects of subsidies for the third+ child on third+ births			
Third child policy	0.008	-0.009	0.027
	(0.013)	(0.013)	(0.031)
Number of regions	198	134	64
N	1,782	1,206	576

Note. For all models, I included crude marriage rates ($t-1$, $t-2$, $t-3$), crude divorce rate ($t-1$), number of women aged 15–49 ($t-1$), the unemployment rate among people aged 30–59 ($t-1$), income per capita ($t-1$), and municipality and year fixed effect in the model. The sample period was 2003–2017 for Panels A and B. To obtain never-treated municipalities, the sample was 2003–2011 for Panel C. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

However, I found that the second child policy raised the number of second children by 5.4%. In the sub-groups, the subsidies for a second child increased second births by 4.5% in urban areas and 6.8% in rural areas. On average, the second child policy promoted the delivery of 29 additional

4 leads, I failed to accept the parallel-trend assumption in the following cases: (1) for the first child policy in rural sample, (2) for the second child policy in urban sample, and (3) for the third child policy in the total and sub-group (i.e., urban and rural) samples.

children.[23] Looking at sub-group analysis, the subsidies for second births encouraged people to have more 35 second children in urban areas and more 9 second children in rural areas.

Table 1.2 describes the effects of childbirth subsidies on the total number of births. To estimate all of the impacts of the three policies at once, I first dropped years 2012 to 2017, allowing five municipalities to serve as a control group. The results show that the first and third child policies failed to increase total births, a reasonable finding given that these two policies did not increase the number of corresponding births in the previous analysis. In contrast, the estimated effects of the second child policy on total births are somewhat confusing. The second child policy did not increase total births in either the full sample or the urban sub-group, even though it positively influenced the number of second births.

Table 1.2: Effects of childbirth subsidy policies on the total number of births

	Full sample	Sub-sample	
		Urban	Rural
Panel A. 2003–2011			
First child policy	-0.003	0.020	-0.024
	(0.015)	(0.017)	(0.024)
Second child policy	0.018	0.006	0.064**
	(0.013)	(0.014)	(0.026)
Third child policy	0.003	-0.004	-0.014
	(0.010)	(0.009)	(0.023)
Number of regions	183	121	62
N	1,647	1,089	558
Panel B. 2003–2017			
First child policy	-0.001	0.006	-0.010
	(0.015)	(0.017)	(0.023)
Second child policy	0.048***	0.032**	0.082***
	(0.016)	(0.016)	(0.029)
Number of regions	183	121	62
N	2,745	1,815	930

Note. All regressions include the full vector of the control variables from Table 1.1. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

[23] Because the average number of second births increased by 5.4% due to the implementation of the second child policy and the average number of second births after policy introduction was 536 births, thus if the local governments in the treatment group had not introduced the second child policy, the average number of second births in those regions would have been 508 births (= 536 / 1.054).

In the sample period 2003–2017, I found that the second child policy increased total births by 4.8% in the full sample, 3.2% in urban areas, and 8.3% in rural areas, even though the magnitudes are quite different from the anticipated effect – 2.1%,[24] 1.8% and 2.7%, respectively – of the second child policy on total births captured through the increase in the number of second births due to the second child policy. One possible scenario is that the second child policy motivated people who want to receive subsidies for a second child to have their first child. However, this interpretation does not seem reasonable, given that even the first child policy was estimated to be ineffective. Another one is that the second child policy had a timing effect, making families more likely to have a third child by advancing the timing of the second childbirth earlier than expected. Considering that TFR in Korea has been recorded around one over the past two decades, this possibility seems to be less likely to happen. That is, either scenario can not fully explain why the estimated effect of the second child policy on total births was greater than the anticipated effect. Further investigation might reveal reasons.

Table 1.3 shows the results from the continuous DID model. In this model, the sum of two estimates (i.e., the coefficient of a dummy variable for policy introduction and the coefficient of an interaction term of the same dummy variable and the subsidy amount) is the policy effect. Although the coefficients for the dummy variables of the first and third child policies were statistically insignificant, the coefficients of the interaction terms in those policies were statistically significant. For entire regions, the first (second) child policy increased the number of first (second) births by 1.4%[25] (5.1%). Still, I had no evidence that the third child policy effectively promoted the birth of a third or subsequent child. However, when I divided the sample into two groups, the results revealed that the coefficients of the interaction terms in the three policies except for the second child policy in rural areas were estimated to be statistically positive,[26] indicating that providing more subsidies is one way to increase the total number of births.

[24] 2.1% results from multiplying the average share of second children among all births in local governments that introduced the second child policy (39%) * effects of the second child policy on the number of second births (5.4%).

[25] Because the average subsidy amount for first births during the sample period was 340,000 won, the policy effect is calculated as 3.4 * 0.4%.

[26] The first child policy effect in urban (rural) areas was 1.1% (2.9%), and the third child policy effect in urban (rural) areas was 0.8% (2.2%). All of these figures were calculated in the same way as previous analyses.

Table 1.3: Effects of childbirth subsidy policies on the number of births: Continuous DID

	Full sample	Sub-sample	
		Urban	Rural
Panel A.The effects of subsidies for the first child on first births			
First child policy	0.007	0.006	0.011
	(0.017)	(0.021)	(0.023)
First child policy * Subsidies (100,000 won)	0.004**	0.006**	0.006***
	(0.002)	(0.003)	(0.002)
Number of regions	190	128	62
N	2,850	1,920	930
Panel B.The effects of subsidies for the second child on second births			
Second child policy	0.051***	0.035**	0.062**
	(0.015)	(0.015)	(0.029)
Second child policy * Subsidies (100,000 won)	0.001	0.002**	0.001
	(0.001)	(0.001)	(0.001)
Number of regions	193	129	64
N	2,895	1,935	960
Panel C.The effects of subsidies for the third+ child on third+ births			
Third child policy	-0.000	-0.020	0.005
	(0.014)	(0.014)	(0.033)
Third child policy * Subsidies (100,000 won)	0.0005*	0.001***	0.001**
	(0.000)	(0.000)	(0.000)
Number of regions	198	134	64
N	1,782	1,206	576

Note. All regressions include the full vector of the control variables from Table 1.1. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

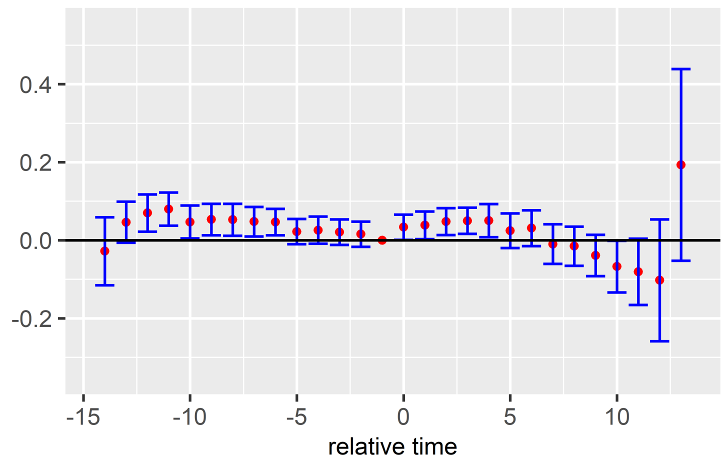
1.5.2 IW estimates

Figure 1.1 illustrates the dynamic policy effects estimated by the IW estimators.[27] As shown in Panel A of Figure 1.1, the first child policy boosted first births until four years after introduction, implying that the policy effect did not persist beyond the early stages of implementation. However, the second child policy continued to increase the number of second births nine years after policy introduction, pushing up the number of second children between 2.8% and 11.6%. After I divided the sample into sub-groups, the overall pattern of the policy intervention effects did not change significantly, but the magnitude of estimated policy effects did. In contrast, I found no statistical evidence that the support program for third or subsequent births motivated households to have a third or subsequent child in the full or sub-group samples.

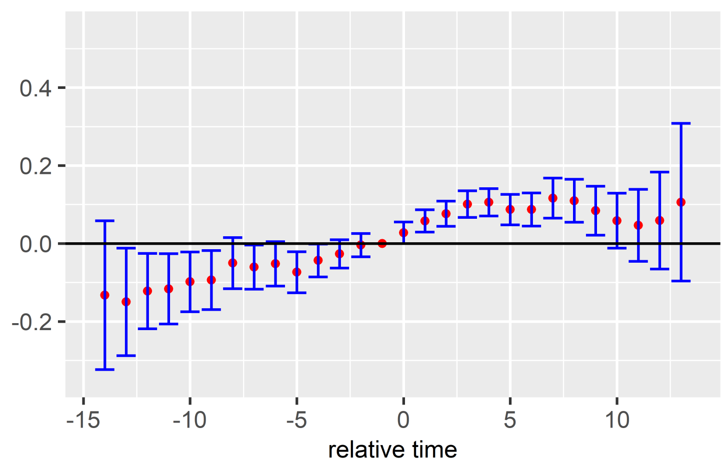
However, when interpreting the results, statistically significant pre-trends emerged for the first and second child policies as shown in Figures 1.1 and 1.2. The observed differences between the treatment and control groups showed downward-sloping pre-trends in the first child policy and upward-sloping pre-trends in the second child policy, indicating violation of the parallel trends assumption and making interpretation of the IW estimates as true policy effects impossible. Accordingly, in the next section, I examine how the IW estimates for the post-periods changed when assuming that these pre-trends continued to exist even after policy implementation.

[27] I tested for heterogeneous treatment effects in all full models before deriving IW estimates. I found heterogeneous treatment effects across cohorts in the first and third child policies in the full sample (relative time 0,3,7,8 for the first child policy and relative time 1,3,4,6 for the third child policy.) When dividing the sample into urban and rural areas, I found heterogeneous treatment effects across cohorts in the three policies in all areas.

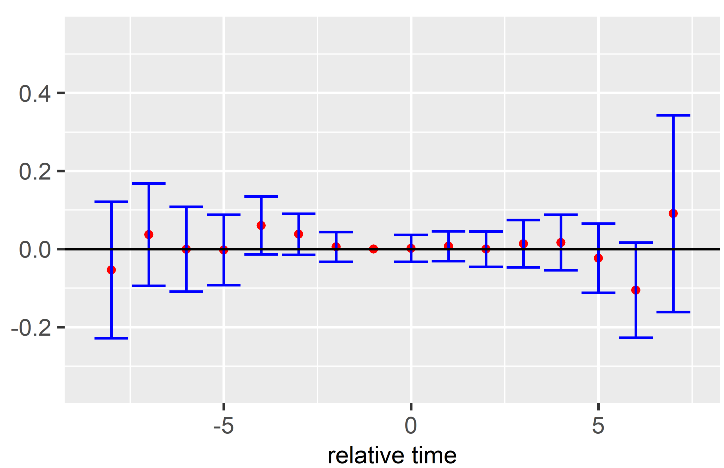
Figure 1.1: Dynamic treatment effects of childbirth subsidy policies (IW estimates)



(a) *Panel A. Effects of first child policy on first births*

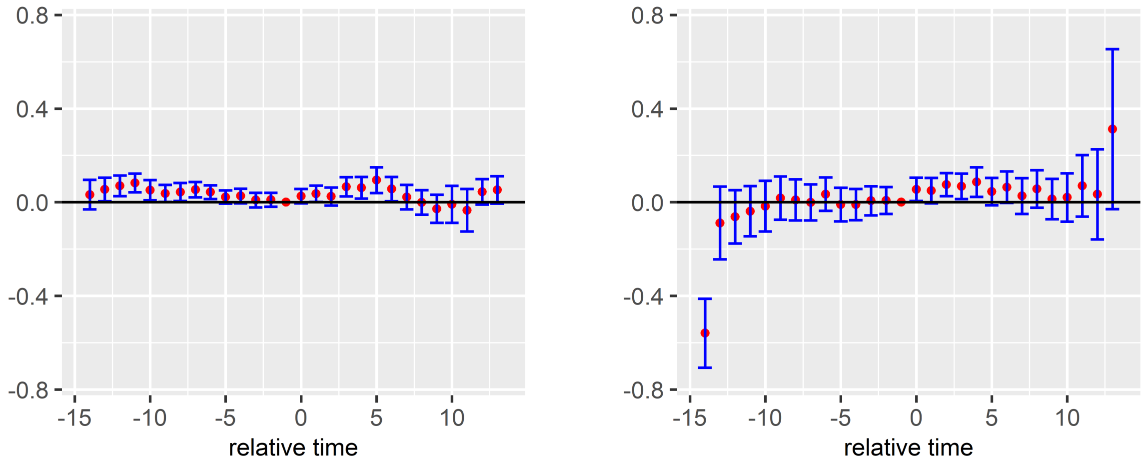


(b) *Panel B. Effects of second child policy on second births*

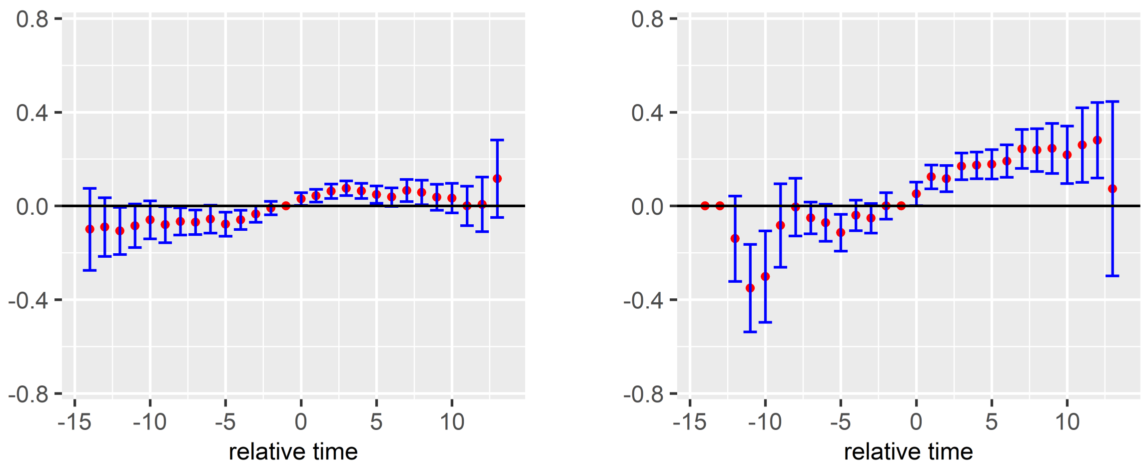


(c) *Panel C. Effects of third child policy on third+ births*

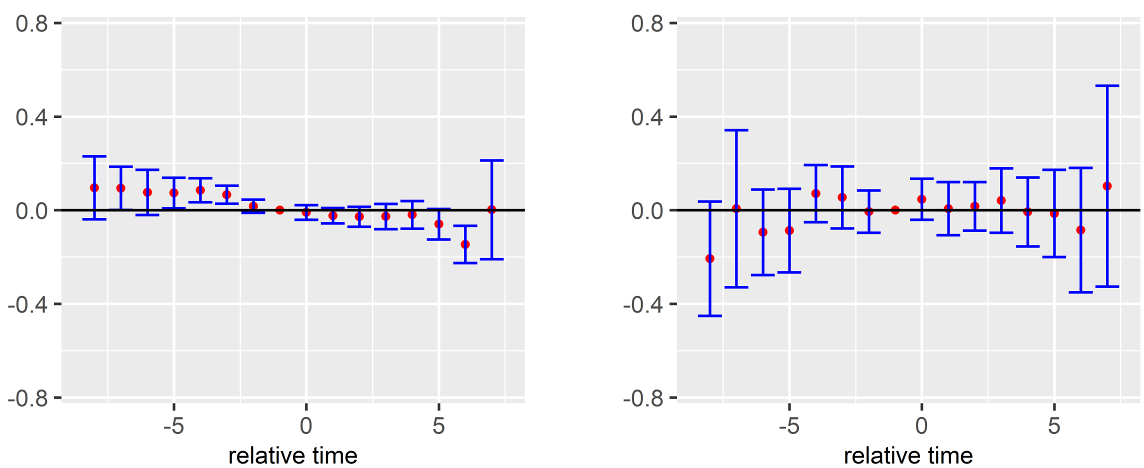
Figure 1.2: Dynamic treatment effects of childbirth subsidy policies: Subgroup analysis (IW)



(a) *Panel A. Effects of first child policy on first births: urban(left) and rural(right)*



(b) *Panel B. Effects of second child policy on second births: urban(left) and rural(right)*



(c) *Panel C. Effects of third child policy on third+ births: urban(left) and rural(right)*

1.6 Sensitivity Analysis

The IW estimates for the pre-periods (i.e., relative time -14 to -2) presented in Section 1.5 show a differential trend in the outcomes for the two groups (i.e., treatment and control groups). Put differently, a statistically significant difference emerged in the number of births between local governments that had already introduced the policy and those that had not yet introduced the same plan, even before policy implementation. This difference might have emerged because each municipality voluntarily started the policies according to their needs rather than random assignment, violating the parallel trend assumption, which is crucial to DID analysis. Therefore, the IW estimates for the post-periods (i.e., relative time 0 to 13) presented in Section 1.5 might be overestimated or underestimated depending on the direction of existing pre-trends, assuming that those trends remained after policy introduction.

To deal with this issue, I adopted the method proposed by Rambachan and Roth (2019). This method allowed me to explore policy effects that might exist, even with the existence of pre-trends. The core idea of this approach is to construct robust confidence sets for parameters of interest by reflecting possible post-trends into already estimated coefficients for post-periods.[28] With this method, the pre-trends assumption does not tightly hold. Instead, pre-trends and their patterns play a critical role in determining the boundaries and directions of post-trends because an observed pre-trend is the only valuable information a regression can yield. In other words, pre-trends serve as the most valid information set for determining possible post-trends. Opening the possibility

[28] Based on the paper of Rambachan and Roth (2019), let $\delta_{pre}, \delta_{post}$ be pre-trends and post-trends, respectively. Let $\hat{\beta}_{pre}, \hat{\beta}_{post}$ be the estimate during pre-periods and post-periods, respectively. $\hat{\beta}(\hat{\beta}_{pre}, \hat{\beta}_{post})$ is an unbiased estimate of $\beta(\beta_{pre}, \beta_{post})$. That is, $\hat{\beta}_n \sim \mathscr{N}(\beta, \Sigma_n)$, where n is the pre-and post-treatment periods. Thus, the average treatment effect on the treated denoted as τ_{ATT} is defined as follow: $\tau_{ATT} = \beta_{post} - \delta_{post}$. The goal is to figure out θ (i.e., the average causal effect during post-periods consistent with τ_{ATT} with the proper assumption for possible post-trends) and to construct confidence sets that are valid for all parameter values θ. That is, assuming $\delta_{pre} = \delta_{post}$, the set of θ can be defined as:

$$\mathscr{S}(\Delta, \tau_{ATT}) = \left\{\theta : \exists \delta \in \Delta \; s.t. \; \delta_{pre} = \beta_{pre}, \, \theta = \hat{\beta}_{post} - \delta_{post}\right\}, \text{ given } \delta(\delta_{pre}, \delta_{post}) \in \Delta$$

And, the confidence sets for all parameter values θ are constructed as follows:

$$\underset{\delta \in \Delta, \tau_{ATT}}{inf} \; \underset{\theta \in \mathscr{S}(\Delta, \delta + \tau_{ATT})}{inf} \mathbb{P}_{(\delta, \tau_{ATT}, \Sigma_n)}(\theta \in \mathscr{C}_n) \geq 1 - \alpha.$$

of post-period differentials between treatment and control groups (post-trends) is more reasonable than maintaining a strong assumption that post-trends are exactly zero because verifying the absence of post-trends is essentially impossible. In DID analysis, the common assumption is that post-trends do not exist if no pre-trends exist, but this relationship is not always true.

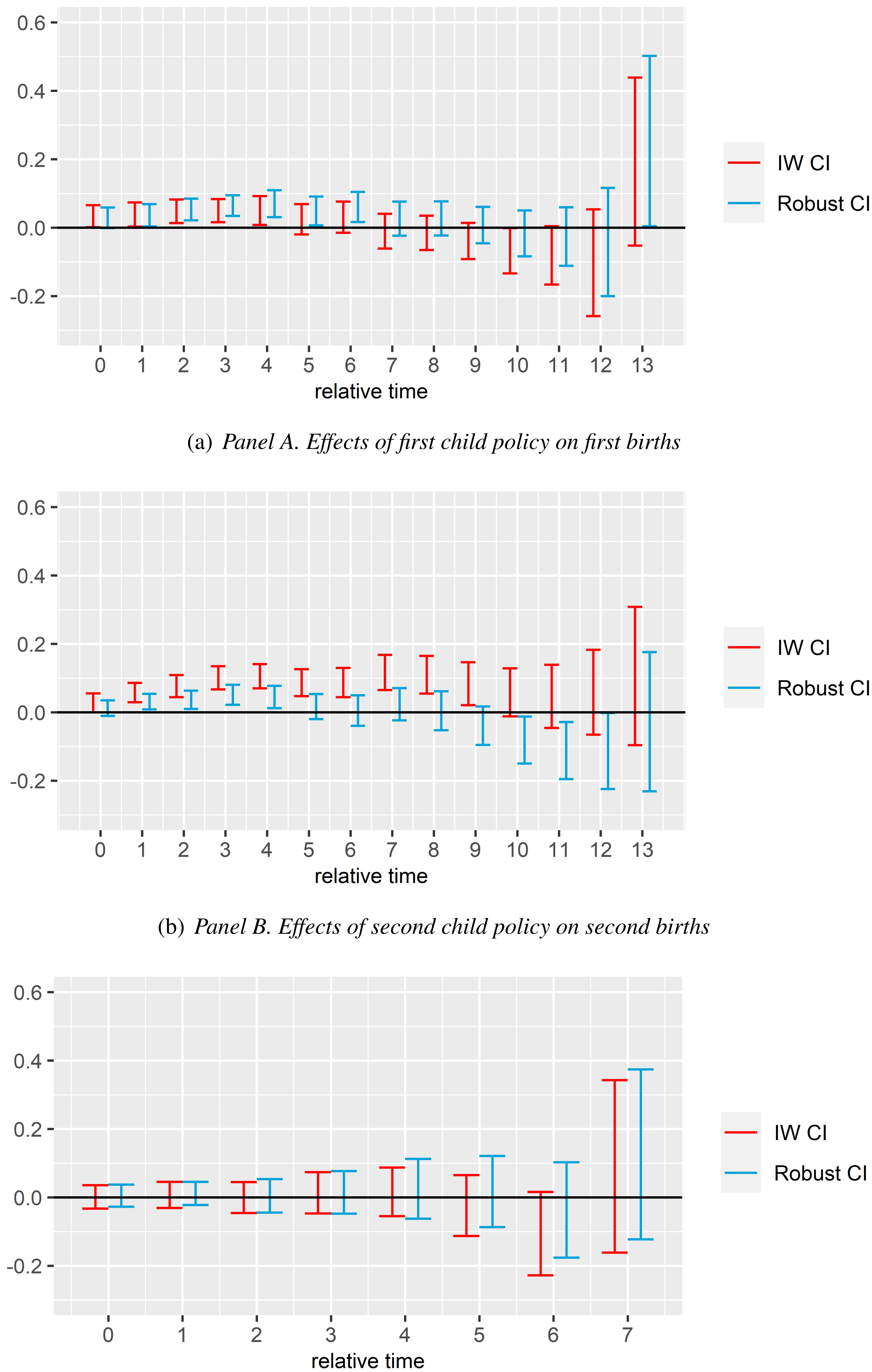
When applying this technique to my analysis, the most important issue is ascertaining the maximum allowable magnitude of the post-trends. In the current study, I assumed that the specific pattern of pre-trends over time (i.e., change in slope of pre-trends) would remain the same even after policy implementation. I also predicted that the pre-trend differences between consecutive times would be linear.[29] Due to multiple pre-periods, several post-trends are possible based on the size of estimated pre-period coefficients and their relationships (i.e., slope among estimated coefficients for pre-periods).

Figure 1.3 shows the confidence intervals I constructed, at the .95 confidence level, for the coefficients of the post-periods. "IW CI" represents the confidence intervals for the IW estimates in Section 1.5. "Robust CI" is the robust confidence sets constructed by assuming a linear trend in the post-periods that matches the observed linear trend in the pre-periods. Panel A in Figure 1.3 illustrates the two different confidence intervals for the effects of the first child policy. According to robust confidence intervals reflecting possible post-trends, the first child policy positively affected first births until six years after local governments started providing subsidies, with greater impacts than those originally predicted by the IW estimators.

Panel B displays the confidence sets for the effects of the second child policy. A noticeable difference exists between the IW confidence sets and the robust confidence sets, clearly showing the IW estimates were overestimated due to pre-trends. Specifically, while the second child policy raised the number of second births in the IW results, the modified confidence intervals reflecting pre-trends (i.e., possible post-trends by assumption) revealed that the policy only slightly encouraged second births in the early years of policy implementation.

[29] Rambachan and Roth (2019) recommended setting various values for possible post-trends, but I assumed linear differences between consecutive periods because the null hypothesis that a linear trend in the treatment groups exists was not rejected. Furthermore, allowing for possible violation of linearity between post-differentials would have yielded a set of confidence intervals that might cause confusion in policy effect interpretation.

Figure 1.3: Robust confidence sets for IW estimates

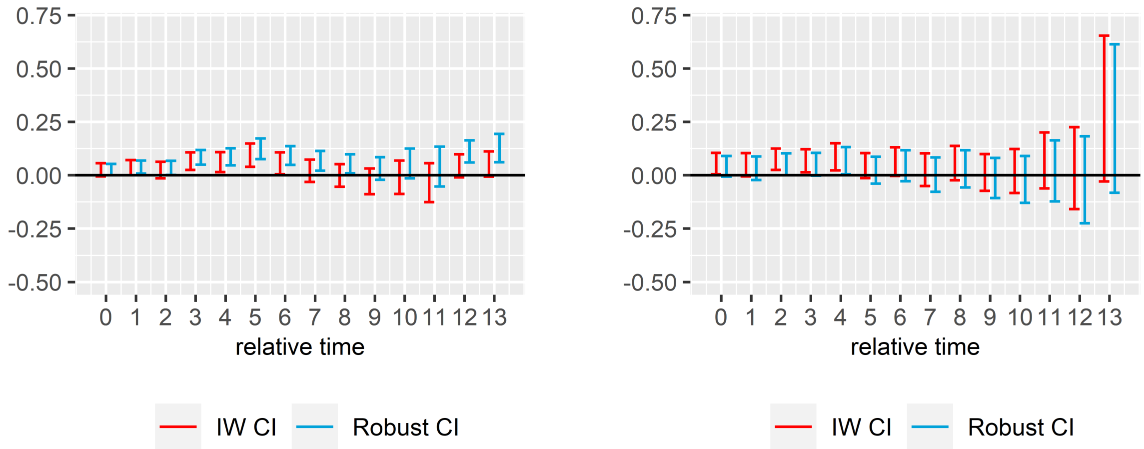


(a) *Panel A. Effects of first child policy on first births*

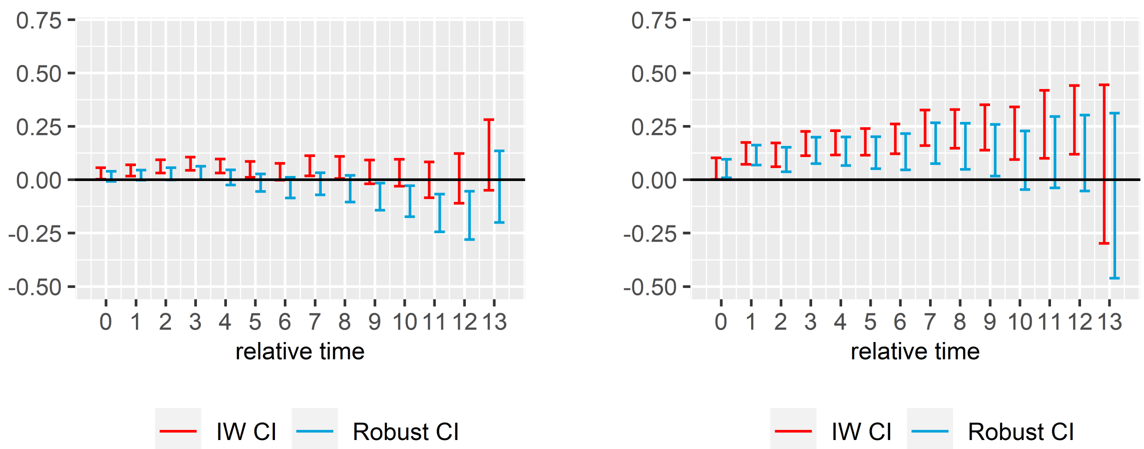
(b) *Panel B. Effects of second child policy on second births*

(c) *Panel C. Effects of third child policy on third+ births*

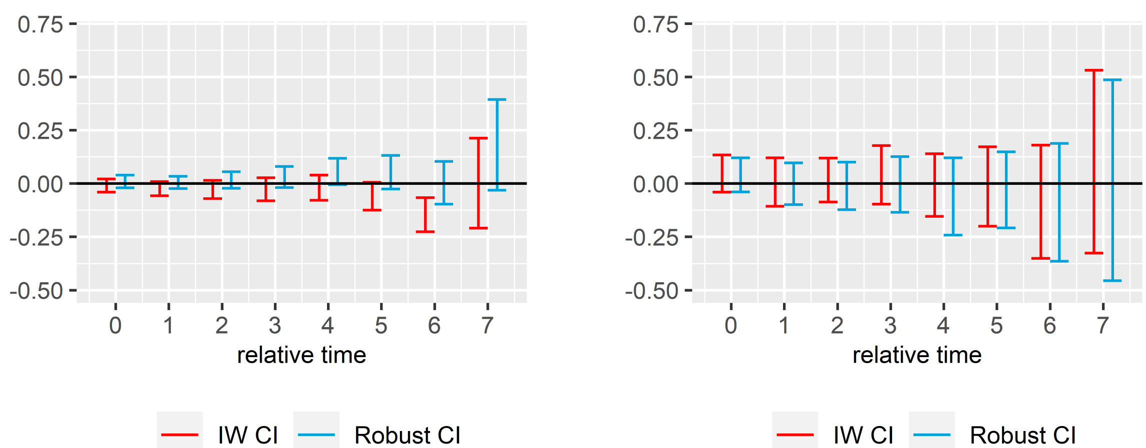
Figure 1.4: Robust confidence sets for IW estimates: Subgroup analysis



(a) *Panel A. Effects of first child policy on first births: urban(left) and rural(right)*



(b) *Panel B. Effects of second child policy on second births: urban(left) and rural(right)*



(c) *Panel C. Effects of third child policy on third+ births: urban(left) and rural(right)*

Panel C shows the two confidence sets for the third model, indicating that the IW estimates were somewhat underestimated. However, more importantly, I found that the third child policy did not encourage having more third or subsequent children. In particular, the robust confidence intervals showed more clearly that the third child policy had no policy effect given that zero is almost in the middle of the robust confidence intervals.

Figure 1.4 presents the robust confidence sets constructed from the sub-group analysis. I found that the first and second child policies affected urban and rural areas differently. More specifically, the first child policy worked more effectively in urban areas than in rural areas to achieve its intended goal based on the continuity and persistency of the policy effects. The second child policy in urban areas did not play a key role in promoting second births. In contrast, the subsidies for a second child in rural areas increased the number of second births until nine years after policy introduction. Similar to the results from the pooled analysis, the third child policy had no impact at all in either region.

Numerically, the lower bound of the actual policy effect of all three policies measured by the increase in the number of births was 10,708,[30] and the upper bound was 54,752. For this outcome, local governments spent a total of $1,866,710,251 over 14 years. In other words, to increase total births by just one child over the 14-year, local governments spent a minimum of $34,094 and a maximum of $174,329.[31]

Finally, when I calculated these figures, I interpreted the policy effect conservatively, meaning that I considered the policy effective only when the confidence intervals were positive. I also assumed that all families eligible to apply for the policies claimed the subsidies and received the money in installments and that subsidies for third or subsequent births had no policy effect, even when extending the analysis period to 2017.[32] Because I derived the marginal cost for an extra birth under somewhat strict assumptions, interpreting these policy effects requires much caution.

[30] See Appendix, Table 1.B18 for details.

[31] In the case of Australia's Baby Bonus, the marginal cost to the government for an additional birth was estimated to be at least $96,923 (Drago et al., 2011).

[32] Considering that only five municipalities were the control group in the analysis, the third policy would still have had no effect in increasing the number of third or subsequent births if the analysis period were extended to 2017. Indeed, this ineffectiveness of the third policy aligns with previous findings (e.g. (Lee, 2014; Park and Song, 2014)

Table 1.4: Total subsidies paid and estimated increases in the total number of births

	Increases in births (n)		Total subsidies paid ($)
	LB	UB	
First (2003–2017)	4,338	22,006	150,522,058
Second (2003–2017)	6,370	32,746	802,665,722
Third (2003–2017)	0	0	913,522,471
Total	10,708	54,752	1,866,710,251

Note. Lower (upper) bound of the increase in the estimated number of births for each post-period is calculated as the average births in reference year * lower (upper) bound of policy effect in the corresponding post-period * the number of local governments in the same post-period. LB (UB) of the increase in the estimated number of births 2003–2017 is the sum of lower (upper) bound of the increase in the estimated number of births for each post-period. Subsidies paid for each post-period is calculated as the average of first (second, third) births in the corresponding post-period * the average of the subsidies for the first (second, third) births in the same post-period * the number of local governments in the same post-period. Total subsidies paid during 2003–2017 are the sum of subsidies paid for each post-period.

1.7 Discussions

Overall, the main results suggest that although Korea's childbirth subsidy policy has played a role in increasing the number of births to some extent, its effectiveness depends on the type of policy (Park and Song, 2014; Son, 2018). My finding that the first and second child policies had heterogeneous effects in urban and rural areas has important implications for policy setting. Average TFR in rural areas tends to be slightly higher than in urban areas,[33] implying that municipalities in rural areas have a higher share of couples considering whether to have a second child than municipalities in urban areas and that municipalities in urban areas have a higher share of families considering whether to have a first child than municipalities in rural areas. Simply put, the first child policy boosted the number of first children in regions with a high share of households deciding whether to have a first child (i.e., urban areas), as did the second child policy. These results suggest that policy effects will increase when local governments determine whom to subsidize based on TFR and demographic characteristics in their respective regions.

[33] See Appendix, Figure 1.A4.

In addition, I concluded from these results that regional fertility-related data played a bigger role than subsidy amount in determining the effectiveness of childbirth subsidy policies, given that subsidy amounts in urban areas tended to be lower than subsidy amounts in rural areas for all policy types.[34] Indeed, providing subsidies for a second or subsequent child in regions where a higher share of people are considering whether to have a first child is meaningless. Likewise, the first child policy will be less effective in places where a higher share of people have a first child regardless of subsidies and then consider having a second child.

Furthermore, no clear evidence shows that the third child policy stimulated third or subsequent births in any region, despite subsidy amounts for third births roughly three times higher than first births in 2017. These results imply that the current policy direction for childbirth incentives in Korea is not the best way to increase total births. The goal of local governments seems to be to increase the intensive margin of childbirth rather than the extensive margin. That is, all local governments introduced the third child policy earlier than the other policies, and the subsidy amounts for third or subsequent births were much greater than the subsidy amounts for first births. However, the fact that TFR in Korea has stayed near one since the 2000s indicates that the share of families who are thinking of having a third child is extremely low. Given that the third child policy has limited beneficiaries and is estimated to have no effect in raising the number of third births, expanding the first child policy in urban areas and the second child policy in rural areas might more effectively increase total births.

1.8 Conclusion

Government officials consider cash-based childbirth incentive policies a vital tool for boosting the number of births in Korea, which has repeatedly hit record lows in TFR. However, doubts about the effectiveness of these policies have long existed. The aim of the current study was to investigate

[34] For the first child policy, the average subsidies in urban areas were higher than those in rural areas from 2007 to 2014. However, considering that families in urban areas generally earn higher monthly salaries than families in rural areas, it is difficult to conclude that a higher subsidy paid during 2007–2014 was the main reason that the first child policy effect implemented by local governments in urban areas was estimated to be effective.

the effects of these programs on childbirth using big data and new methods to address econometric concerns that might arise in a multiple treatment setting with pre-existing trends.

In the total sample, the results show that the childbirth subsidies for first and second children increased the number of corresponding children. However, no evidence shows that the subsidies for third or subsequent children motivated families to have a third or subsequent child. However, in the sub-group analysis, I found that subsidizing families with a new first child incentivized people to have a first child in urban areas, whereas the same policy did not in rural areas. On the other hand, subsidizing families with a new second child incentivized people to have a second child in rural areas, whereas the same policy did not in urban areas. The results suggest that local governments can enhance the effectiveness of policies by considering TFR and demographic characteristics in their respective regions, given that the average TFR in rural areas is slightly closer to two.

Even though the results suggest that the subsidies that encourage first and second births increased the number of first and second births to some degree, alternative procedures might be necessary considering that Korea still has the lowest TFR in the world. Lowering the cost of education,[35] increasing the number of preschools, building a family-friendly workplace, and improving the perception of gender roles both in the workplace and in the family are additional ways to deal with a continually falling fertility rate based on surveys conducted in Korea.[36]

I acknowledge the limitations of this study. The first is the possibility of measurement error. The criteria for determining birth order differ between Statistics Korea and local governments.

[35] According to data from Statistics Korea, the average monthly private education cost per person in 2019 was 321,000 won, which is 12% of the average monthly salary for wage workers. Private education costs vary greatly with income level. The average private education spending of households with a monthly income of less than 2 million won was 104,000 won, while that of households with a monthly income of more than 8 million won was 539,000 won, corresponding to 4% and 20% of the average monthly salary for wage workers in 2019. increasing the number of preschools, building a family-friendly workplace, and improving the perception of gender roles both in the workplace and in the family are additional ways to deal with a continually falling fertility rate based on surveys conducted in Korea.

[36] According to the results of a survey conducted by Seoul metropolitan city, the actual reasons reported for low birthrate are the following: (a) high cost of children's education (49.3%), (b) high cost of pregnancy and childcare (44.4%), (c) lack of childcare facilities or supporting resources (33.9%), (d) work and life imbalance (25.8%), (e) career breaks caused by childbirth and parenting (16.7%), (f) unequal social perception of women's roles in pregnancy, childbirth, and childcare (8.5%), and (g) discriminatory working environment (8.2%). The survey was conducted via phone interview with 1,000 citizens of Seoul aged at least 19 years, extracted by stratified random sampling by region, sex, and age.

Statistics Korea categorizes birth order based on the overall history of childbirth for a woman, regardless of marital status, while local governments provide childbirth subsidies based on the birth order in a family currently maintained. Second, I did not control for the effects of temporary migration to receive subsidies. However, each government specifies the necessary residence periods of families with a new baby in order to receive support in that region, and the split-payment method for higher subsidies minimizes temporary migration. Therefore, the potential effect of internal migration and immigration caused by subsidy amount is likely to be trivial.

Finally, I did not identify whether increases in first children were due to adjustments in the timing of childbirth or an increase in completed fertility. Choo (2021) found that the childbirth subsidy policies currently implemented in Korea only have a timing effect. However, a rational decision-maker is less likely to have given birth earlier than expected, for the subsidy amounts continue to increase over time. Thus, even though a timing effect might be part of the estimated effects, the total impact of the first child policy estimated in this study is not necessarily due to a timing effect.

Despite these limitations, the findings of this study show that programs designed to help families financially led to an increase in the number of first and second births in entire regions. Even if the effect of the first child policy estimated in this study is only due to a timing effect, as Choo (2021) found, the first child policy is still meaningful because it raises the possibility of having a second child by encouraging birth of the first child earlier than expected. Although these findings derive from data specific to Korea, it has implications for other countries with characteristics similar to Korea.

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OECD (https://data.oecd.org)

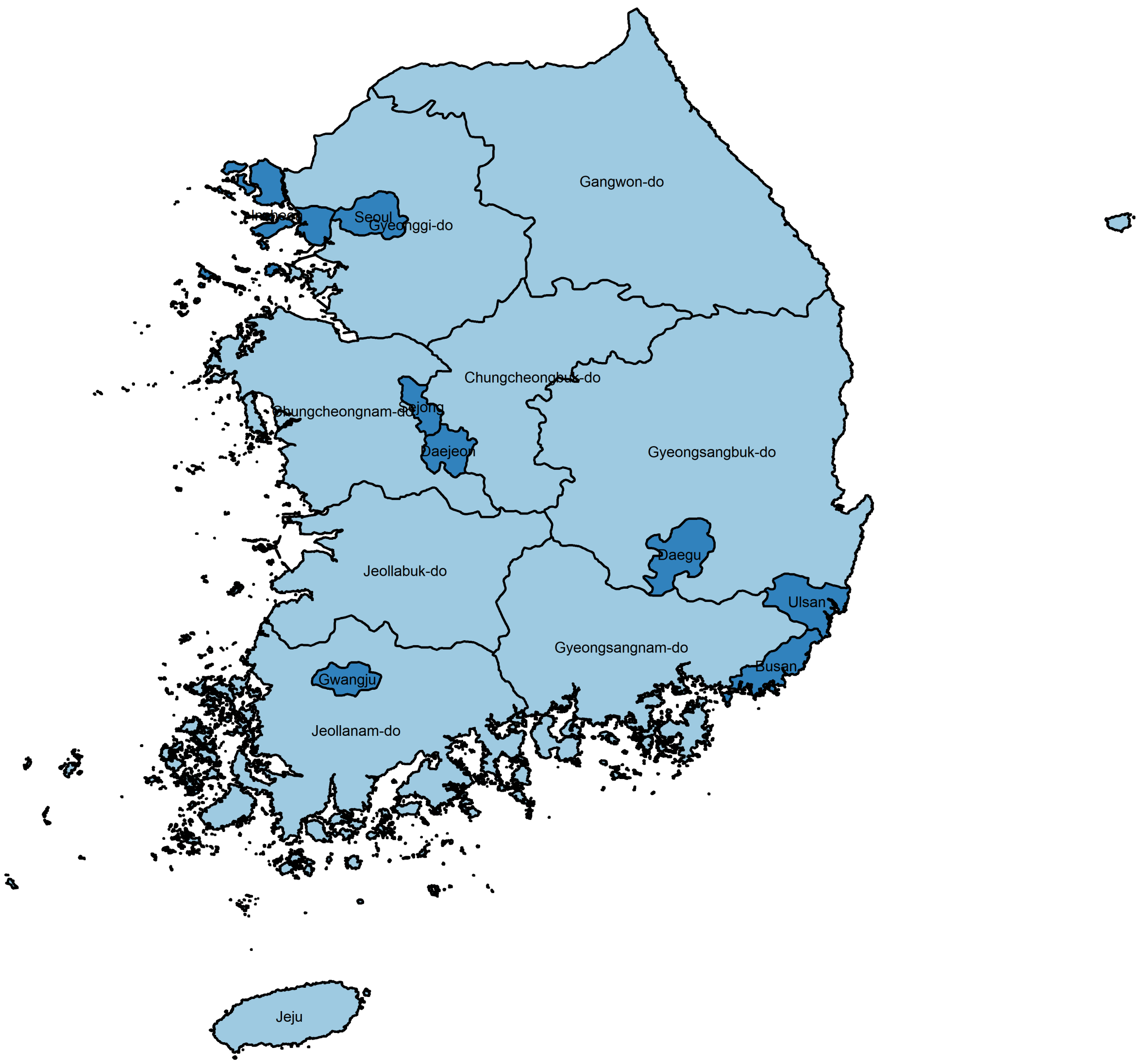
Seoul Metropolitan Council (https://www.smc.seoul.kr)

Statistics Korea (http://kostat.go.kr)

The National Law Information Center (http://www.law.go.kr)

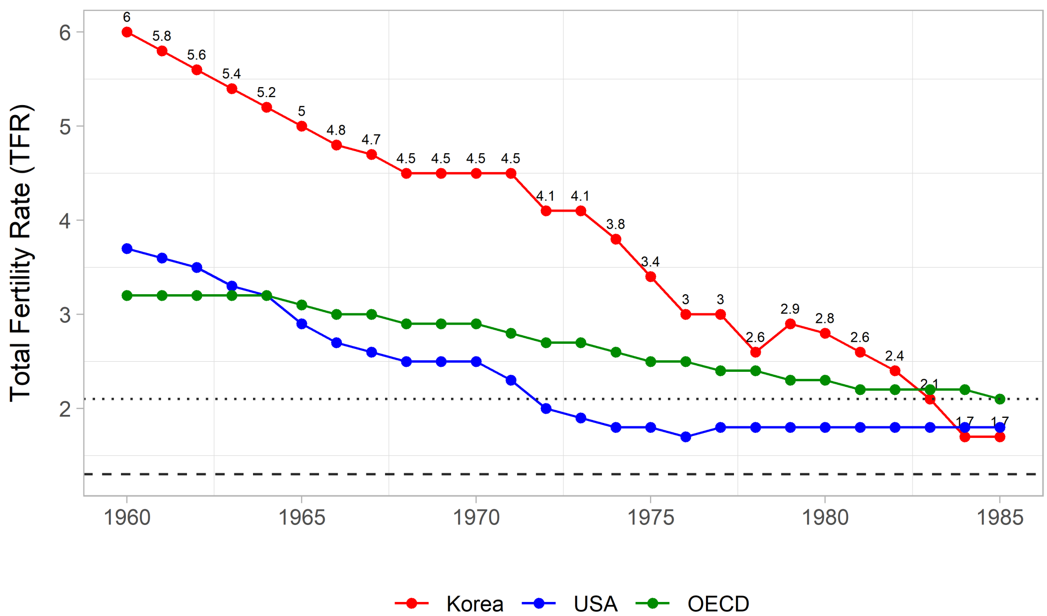
Appendix A. Figures

Figure 1.A1: A map of the administrative district of Korea at the metropolitan level

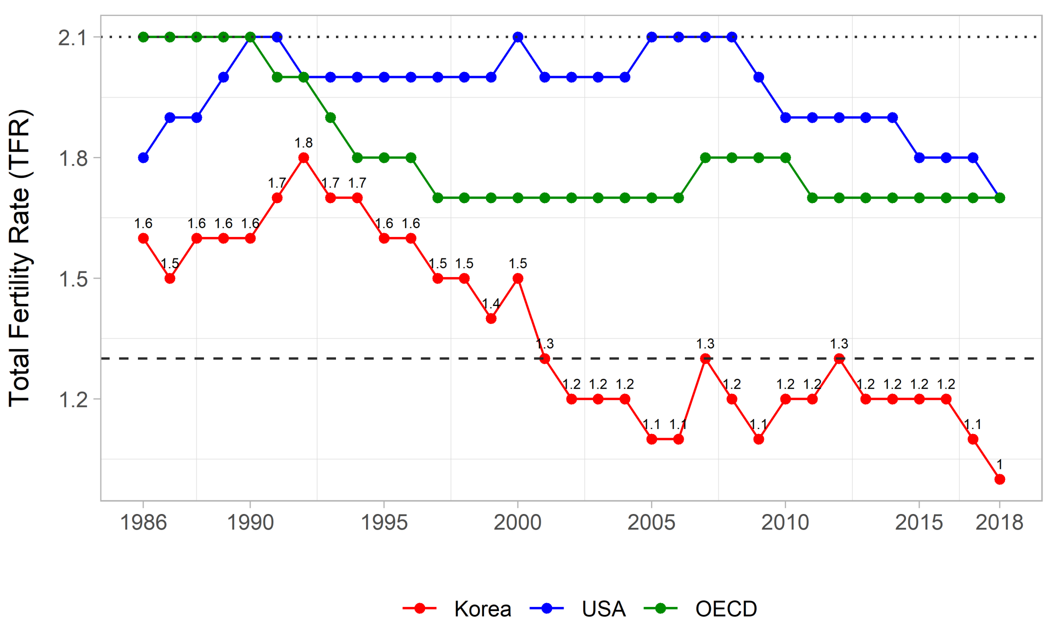


Note. Korea has eight metropolitan cities (Seoul, Busan, Daegu, Incheon, Gwanju, Daejeon, Ulsan, and Sejong; shaded dark blue), nine provinces (Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do, Gyeongsangnam-do, and Jeju-do; shaded light blue). Among them, Seoul Metropolitan City is the capital of South Korea, accounting for about one-fifth of the total population.

Figure 1.A2: Trends in total fertility rate (1960-2018)



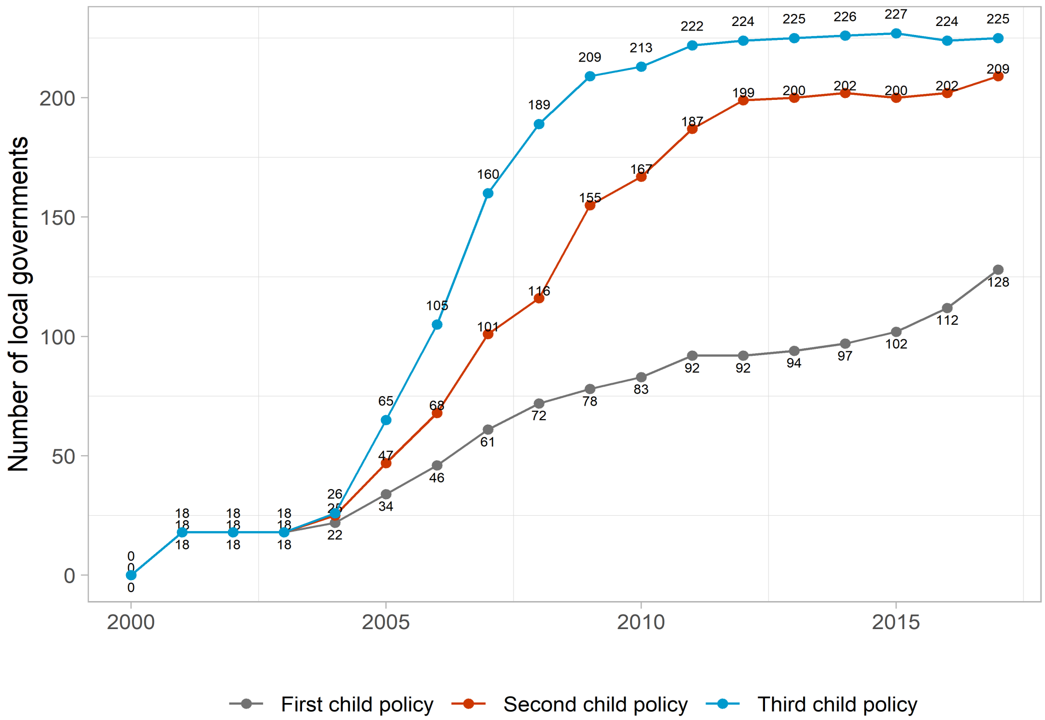
(a) *Panel A. Trends in total fertility rate (1960-1985)*



(b) *Panel B. Trends in total fertility rate (1986-2018)*

Data. OECD.
Note. The dotted line represents the population replacement rate (TFR 2.1), and the dashed line represents a criterion commonly used to determine whether a country is an ultra-low birth rate country.

Figure 1.A3: The number of municipalities introducing childbirth subsidy policies by birth order

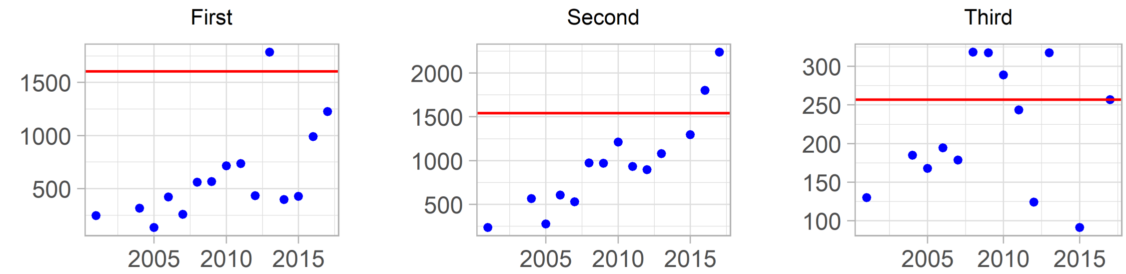


Data. 228 local governments.

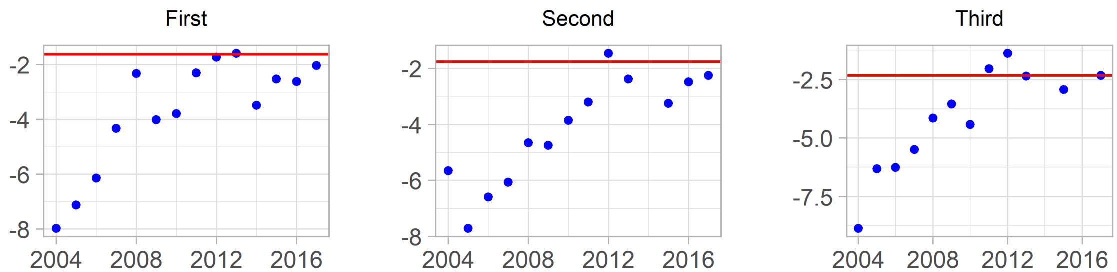
Figure 1.A4: The average total fertility rate: urban areas and rural areas

Data. Statitics Korea.
Note. Because these data result from secondary processing, TFR in this figure might differ slightly from TFR obtained by the sum of current age-specific fertility rates in urban and rural areas.

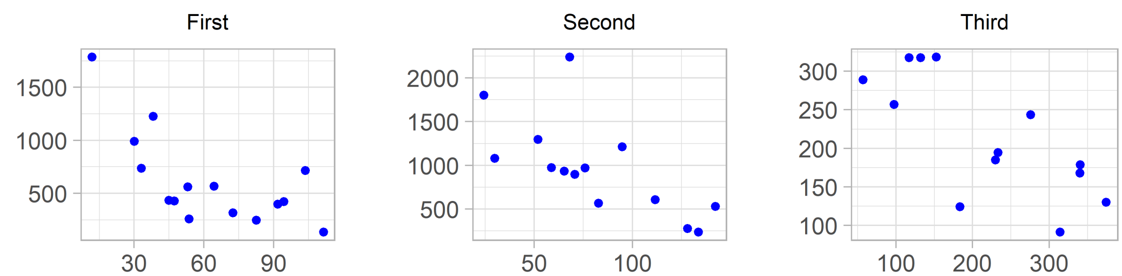
Figure 1.A5: The relationship between the average number of births and the year of policy introduction (the average subsidies) by cohort



(a) *Panel A. The average number of births during pre-periods and the year of policy introduction*



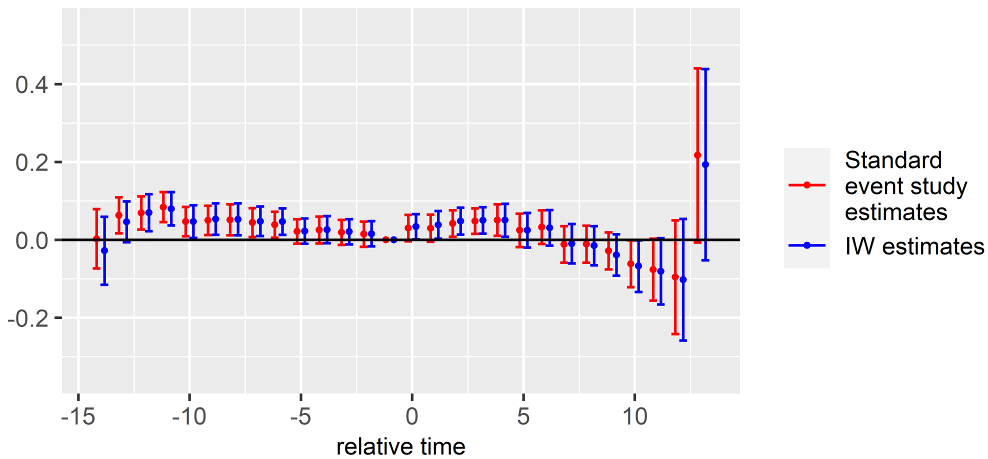
(b) *Panel B. The average decrease rate of number of births during pre-periods*



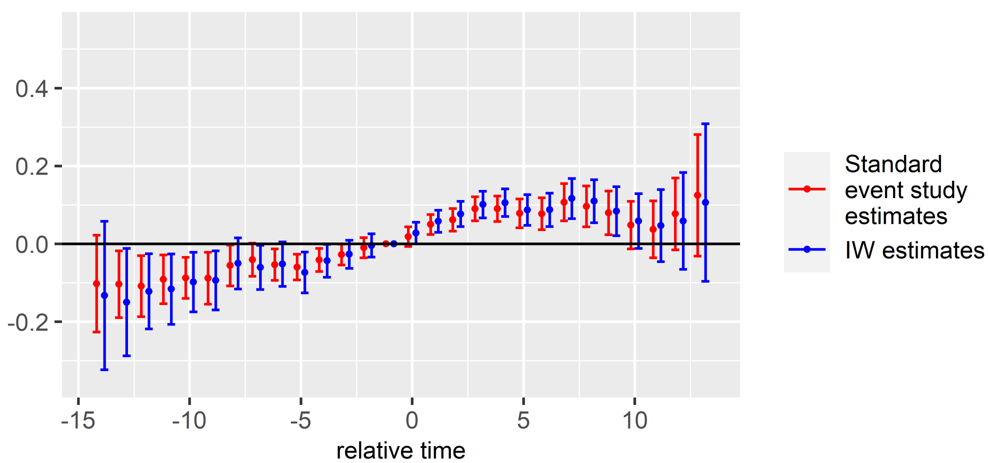
(c) *Panel C. The average number of births during pre-periods and the average subsidies during post-periods*

Data. 228 local governments.
Note. In Panel A, the y-axis represents the average number of births before policy introduction, and the x-axis represents the year of policy introduction. In Panel B, the y-axis represents the average rate of decrease in the number of births during the pre-periods, and the x-axis represents the year of policy introduction. In Panel C, the y-axis represents the average number of births before policy introduction, and the x-axis represents the average subsidies in Korean currency (unit: 10,000 won). The red vertical lines in the first and second graphs describe the figures in municipalities used as a control group in analysis.

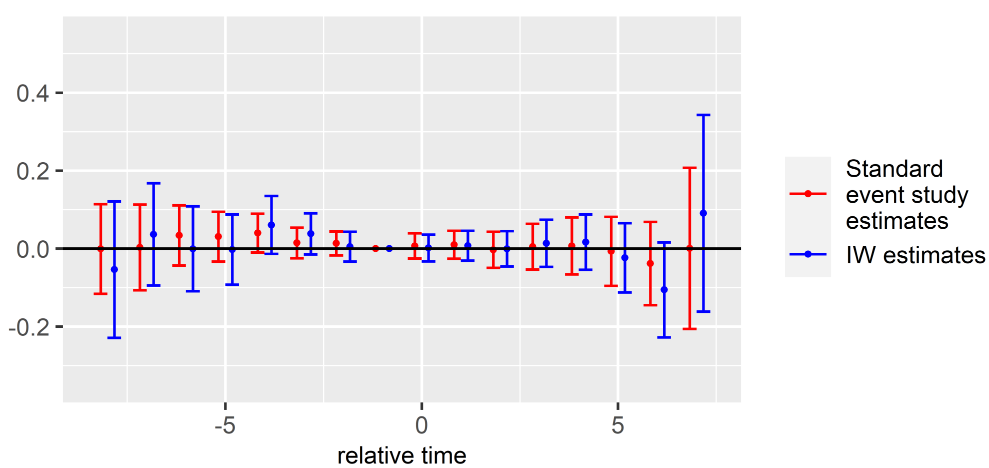
Figure 1.A6: Dynamic treatment effects of childbirth subsidy policies



(a) *Panel A. Effects of first child policy on first births*

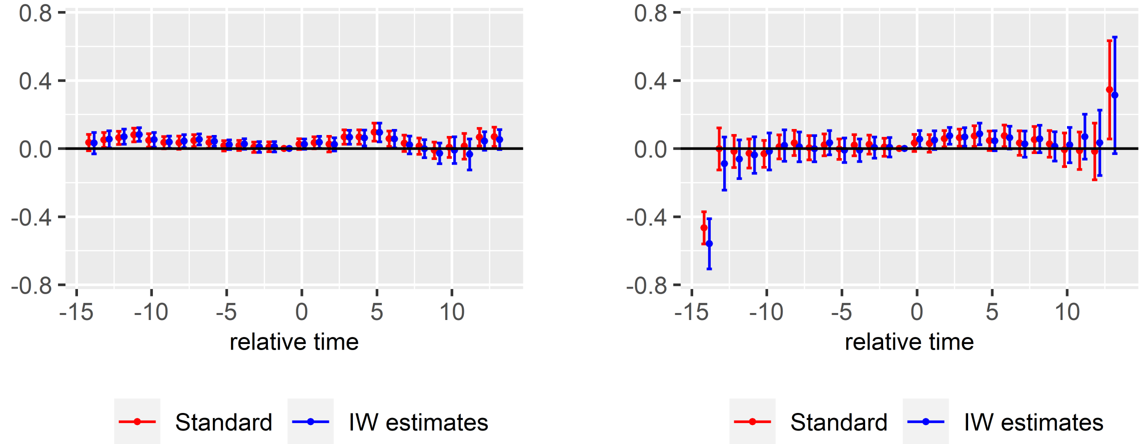


(b) *Panel B. Effects of second child policy on second births*

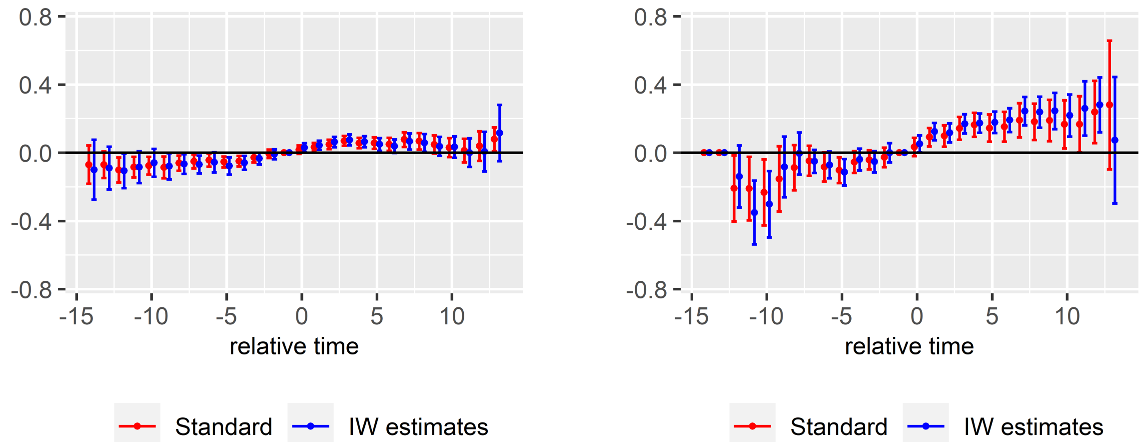


(c) *Panel C. Effects of third child policy on third+ births*

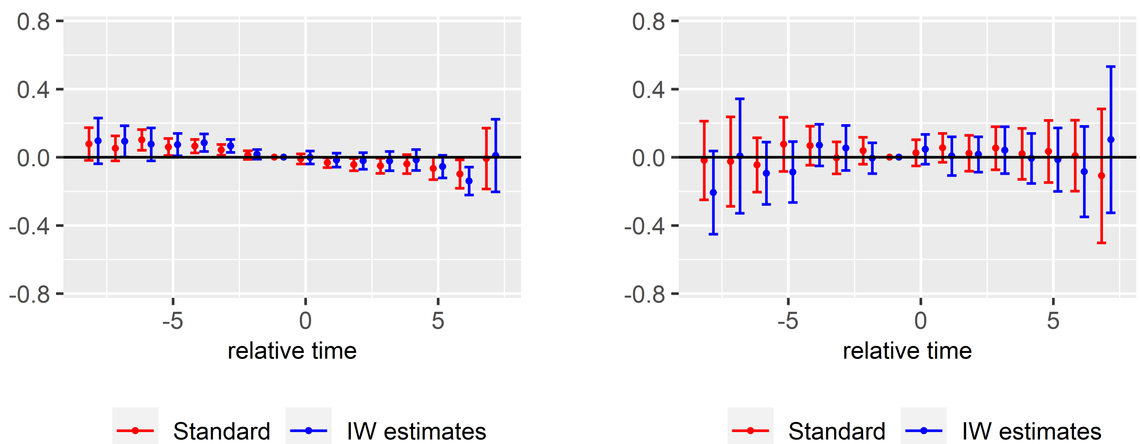
Figure 1.A7: Dynamic treatment effects of childbirth subsidy policies: Subgroup analysis



(a) *Panel A. Effects of first child policy on first births: urban(left) and rural(right)*



(b) *Panel B. Effects of second child policy on second births: urban(left) and rural(right)*



(c) *Panel C. Effects of third child policy on third+ births: urban(left) and rural(right)*

Appendix B. Tables

Table 1.B1: The number of municipalities introducing the childbirth subsidy policy

Year	First child policy			Second child policy			Third child policy		
	N	Split	Urban	*N*	Split	Urban	N	Split	Urban
2001	18	0 (0)	0 (0)	18	0 (0)	0 (0)	18	1 (6)	0 (0)
2002	18	0 (0)	0 (0)	18	0 (0)	0 (0)	18	1 (6)	0 (0)
2003	18	0 (0)	0 (0)	18	0 (0)	0 (0)	18	1 (6)	0 (0)
2004	22	1 (5)	1 (5)	25	1 (4)	4 (16)	26	1 (4)	5 (19)
2005	34	3 (9)	2 (6)	47	3 (6)	13 (28)	65	6 (9)	24 (37)
2006	46	8 (17)	8 (17)	68	10 (15)	26 (38)	105	20 (19)	57 (54)
2007	61	13 (21)	17 (28)	101	30 (30)	44 (44)	160	53 (33)	91 (57)
2008	72	15 (21)	21 (29)	116	33 (28)	55 (47)	189	74 (39)	115 (61)
2009	78	20 (26)	25 (32)	155	42 (27)	87 (56)	209	96 (46)	133 (64)
2010	83	22 (27)	28 (34)	167	49 (29)	96 (57)	213	106 (50)	137 (64)
2011	92	24 (26)	32 (35)	187	64 (34)	110 (59)	222	118 (53)	142 (64)
2012	92	24 (26)	30 (33)	199	71 (36)	120 (60)	224	122 (54)	143 (64)
2013	94	25 (27)	32 (34)	200	73 (37)	121 (61)	225	121 (54)	144 (64)
2014	97	27 (28)	35 (36)	202	76 (38)	123 (61)	226	123 (54)	145 (64)
2015	102	27 (26)	37 (36)	200	81 (41)	119 (60)	227	129 (57)	145 (64)
2016	112	33 (29)	42 (38)	202	84 (42)	121 (60)	224	133 (59)	142 (63)
2017	128	42 (33)	56 (44)	209	89 (43)	128 (61)	225	134 (60)	143 (64)

Data. 228 local governments and 17 metropolitan governments.
Note. There are two types of subsidy payment methods: lumpsum and split-payment. The “Split” columns present the number of municipalities using the split-payment method. The figures in parentheses in the “Split” columns refer to the proportion of local governments using the split-payment method. The “Urban” columns present the number of local governments in urban areas that enacted childbirth policies. The figures in parentheses in the “Urban” columns represent the proportion of local governments in urban areas that implemented the policy.

Table 1.B2: The amount of subsidy for the first births

Year	The average subsidy amount	The percentage of average monthly salary (%)	Payment method		Character of area	
			Lumpsum	Split	Urban	Rural
2001	21 ($188)	-	21	0	0	21
2002	21 ($184)	-	21	0	0	21
2003	33 ($292)	-	33	0	0	33
2004	45 ($402)	22 (30)	43	86	39	46
2005	50 ($439)	24 (34)	41	137	38	50
2006	59 ($524)	29 (40)	42	139	34	65
2007	87 ($767)	41 (56)	41	256	107	79
2008	78 ($694)	37 (52)	39	228	97	71
2009	83 ($733)	40 (61)	41	203	97	76
2010	83 ($730)	39 (60)	45	188	92	78
2011	81 ($716)	38 (57)	46	181	86	78
2012	86 ($765)	40 (60)	44	207	98	81
2013	86 ($761)	39 (59)	43	205	91	83
2014	85 ($754)	38 (58)	43	194	88	84
2015	87 ($768)	38 (59)	47	199	86	87
2016	88 ($775)	37 (59)	46	187	73	96
2017	103 ($907)	43 (67)	47	217	70	128

Data. 228 local governments and 17 metropolitan governments.
Note. The unit of subsidies is 10,000 won in Korean currency. Subsidies have been adjusted using CPI. The figures in parentheses in column 2 refer to subsidy amounts converted into dollars, calculated by applying the exchange rate of 2017 provided by the Bank of Korea, which is $1 = 1,130.84 won. The figures corresponding to row 1 through row 3 in column 3 were not calculated due to lack of relevant data. The figures in parentheses in column 3 refer to the percentage of average monthly salary for non-regular workers. Columns 4 and 5 show subsidy amounts by payment method. Columns 6 and 7 indicate subsidy amounts by character of local government.

Table 1.B3: The amount of subsidy for the second births

Year	The average subsidy amount	The percentage of average monthly salary (%)	Payment method		Character of area	
			Lumpsum	Split	Urban	Rural
2001	21 ($188)	-	21	0	0	21
2002	21 ($184)	-	21	0	0	21
2003	33 ($292)	-	33	0	0	33
2004	44 ($386)	22 (29)	42	86	33	46
2005	53 ($471)	26 (36)	42	218	42	58
2006	70 ($617)	34 (47)	47	205	51	81
2007	111 ($982)	52 (71)	54	247	88	129
2008	101 ($898)	47 (67)	52	226	80	121
2009	103 ($914)	49 (76)	51	244	72	143
2010	104 ($918)	48 (75)	51	232	70	149
2011	108 ($959)	51 (76)	49	223	70	163
2012	111 ($983)	51 (77)	50	222	74	167
2013	113 ($999)	51 (77)	50	223	74	172
2014	115 ($1,013)	51 (78)	53	217	76	174
2015	118 ($1,045)	51 (80)	53	213	75	181
2016	126 ($1,115)	54 (85)	53	229	75	202
2017	143 ($1,269)	61 (94)	57	261	82	241

Data. 228 local governments and 17 metropolitan governments.
Note. The unit of subsidies is 10,000 won in Korean currency. Subsidies have been adjusted using CPI. The figures in parentheses in column 2 refer to subsidy amounts converted into dollars, calculated by applying the exchange rate of 2017 provided by the Bank of Korea, which is $1 = 1,130.84 won. The figures corresponding to row 1 through row 3 in column 3 were not calculated due to lack of relevant data. The figures in parentheses in column 3 refer to the percentage of average monthly salary for non-regular workers. Columns 4 and 5 show subsidy amounts by payment method. Columns 6 and 7 indicate subsidy amounts by character of local government.

Table 1.B4: The amount of subsidy for the third or higher births

Year	The average subsidy amount	The percentage of average monthly salary (%)	Payment method		Character of area	
			Lumpsum	Split	Urban	Rural
2001	78 ($686)	-	14	1155	0	78
2002	76 ($674)	-	14	1135	0	76
2003	87 ($769)	-	27	1106	0	87
2004	86 ($764)	43 (57)	47	1070	79	88
2005	123 ($1,084)	60 (83)	61	725	100	136
2006	161 ($1,421)	78 (107)	64	573	96	237
2007	235 ($2,081)	111 (151)	86	537	137	365
2008	237 ($2,093)	110 (157)	94	458	150	371
2009	255 ($2,255)	122 (187)	111	425	164	415
2010	267 ($2,365)	125 (193)	108	428	176	433
2011	301 ($2,658)	140 (211)	121	459	201	477
2012	303 ($2,680)	139 (210)	120	456	206	474
2013	306 ($2,710)	137 (210)	125	462	205	487
2014	309 ($2,729)	137 (210)	125	463	213	480
2015	312 ($2,757)	135 (212)	113	463	191	524
2016	336 ($2,972)	143 (227)	112	490	199	574
2017	363 ($3,207)	154 (238)	126	524	207	633

Data. 228 local governments and 17 metropolitan governments.
Note. The unit of subsidies is 10,000 won in Korean currency. Subsidies have been adjusted using CPI. The figures in parentheses in column 2 refer to subsidy amounts converted into dollars, calculated by applying the exchange rate of 2017 provided by the Bank of Korea, which is $1 = 1,130.84 won. The figures corresponding to row 1 through row 3 in column 3 were not calculated due to lack of relevant data. The figures in parentheses in column 3 refer to the percentage of average monthly salary for non-regular workers. Columns 4 and 5 show subsidy amounts by payment method. Columns 6 and 7 indicate subsidy amounts by character of local government.

Table 1.B5: Descriptive statistics

	Full sample		Urban areas		Rural areas	
	Control	Treated	Control	Treated	Control	Treated
Panel A. First policy (2003–2017)						
N (# of municipalities)	1,350 (90)	1,500 (100)	1,215 (81)	705 (47)	135 (9)	795 (53)
Births (*n*)	1,575	555	1,728	973	204	183
Subsidies (10,000 won)	–	34	–	19	–	48
Crude marriage rate (%)	6.3	5.3	6.4	5.7	5.5	4.9
Crude divorce rate (%)	2.6	2.3	2.6	2.4	2.4	2.2
Unemployment rate aged 30-59 (%)	2.6	2	2.7	2.2	1.9	1.9
Income per capita (1,000,000 won))	15.3	14.2	15.5	14.4	13.8	14
Number of women aged 15-49 (*n*)	89,115	32,755	97,732	57,382	11,565	10,916
Panel B. Second policy (2003–2017)						
N (# of municipalities)	195 (13)	2,700 (180)	180 (12)	1,755 (117)	15 (1)	945 (63)
Births (*n*)	1,512	693	1,630	982	97	155
Subsidies (10,000 won)	–	64	–	38	–	112
Crude marriage rate (%)	6.7	5.7	6.6	6	7.1	4.9
Crude divorce rate (%)	2.7	2.4	2.7	2.4	2.4	2.2
Unemployment rate aged 30-59 (%)	2.2	2.3	2.3	2.5	1.5	1.9
Income per capita (1,000,000 won)	14.6	14.8	14.7	15.3	13.2	14
Number of women aged 15-49 (*n*)	101,350	55,928	109,386	79,987	4,920	11,249
Panel C. Third policy (2003–2011)						
N (# of municipalities)	45 (5)	1,737 (193)	27 (3)	1,179 (131)	18 (2)	558 (62)
Births (*n*)	176	196	249	261	68	57
Subsidies (10,000 won)	–	128	–	84	–	221
Crude marriage rate (%)	5.8	5.9	6.4	6.3	4.9	5.1
Crude divorce rate (%)	2.5	2.5	2.8	2.7	2.2	2.2
Unemployment rate aged 30-59 (%)	1.8	2.4	1.9	2.6	1.7	1.9
Income per capita (1,000,000 won)	13	14	13.2	14.4	12.8	13.2
Number of women aged 15-49 (*n*)	41,869	61,385	59,720	84,947	15,093	11,600

Data. 228 local governments and 17 metropolitan governments, Statistics Korea.
Note. Subsidies and Income per capita have been adjusted using CPI, base year 2015.

Table 1.B6: Sample characteristics for the first births by cohort (2003 – 2017)

	N (Cohort)	Mean (Pre-births)	Mean (Post-births)	Mean (Subsidies)	Std. Dev (Subsidies)
Cohort 2004	4	266	272	72	70
Cohort 2005	11	115	103	111	145
Cohort 2006	9	374	341	94	74
Cohort 2007	12	233	241	54	59
Cohort 2008	11	457	439	50	31
Cohort 2009	4	515	399	64	43
Cohort 2010	4	775	679	50	34
Cohort 2011	7	572	554	26	16
Cohort 2012	3	424	623	45	41
Cohort 2013	2	1,709	1,638	12	4
Cohort 2014	2	368	285	92	27
Cohort 2015	7	401	311	47	42
Cohort 2016	10	952	721	30	36
Cohort 2017	14	1,177	931	38	52
Control group	90	1,575	1,575	-	-

Data. 228 local governments and 17 metropolitan governments, Statistics Korea.
Note. The unit of subsidies is 10,000 won in Korean currency. The unit of income per capita is 1,000,000 won in Korean currency. Subsidies and income per capita have been adjusted using CPI.

Table 1.B7: Sample characteristics for the second births by cohort (2003 – 2017)

	N (Cohort)	Mean (Pre-births)	Mean (Post-births)	Mean (Subsidies)	Std. Dev (Subsidies)
Cohort 2004	7	508	393	83	94
Cohort 2005	22	234	191	128	162
Cohort 2006	20	529	506	112	86
Cohort 2007	31	443	423	145	158
Cohort 2008	14	876	712	54	41
Cohort 2009	38	856	776	76	92
Cohort 2010	9	1,203	1,061	66	70
Cohort 2011	19	838	748	62	68
Cohort 2012	7	842	900	71	60
Cohort 2013	1	996	913	30	0
Cohort 2015	4	1,201	928	52	30
Cohort 2016	2	1,701	1,362	24	10
Cohort 2017	6	2,105	1,662	68	24
Control group	13	1,512	1,512	-	-

Data. 228 local governments and 17 metropolitan governments, Statistics Korea.
Note. The unit of subsidies is 10,000 won in Korean currency. The unit of income per capita is 1,000,000 won in Korean currency. Subsidies and income per capita have been adjusted using CPI.

Table 1.B8: Sample characteristics for the third or higher births (2003 – 2011)

	N (Cohort)	Mean (Pre-births)	Mean (Post-births)	Mean (Subsidies)	Std. Dev (Subsidies)
Cohort 2004	8	154	154	152	167
Cohort 2005	37	142	144	267	361
Cohort 2006	39	164	178	179	164
Cohort 2007	51	155	168	306	357
Cohort 2008	28	289	288	136	237
Cohort 2009	18	287	295	99	82
Cohort 2010	3	259	278	56	20
Cohort 2011	9	227	263	270	242
Control group	5	176	176	-	-

Data. 228 local governments and 17 metropolitan governments, Statistics Korea.
Note. I adjusted the analysis period 2003–2011 by dropping six years to obtain a control group of five municipalities that had introduced the policy for third or subsequent births since 2012. The unit of subsidies is 10,000 won in Korean currency. The unit of income per capita is 1,000,000 won in Korean currency. Subsidies and income per capita have been adjusted using CPI.

Table 1.B9: Effects of first child policy on first births (2003-2017)

Relative time	Full sample		Sub-sample			
			Urban		Rural	
	Standard	IW	Standard	IW	Standard	IW
-14	0.003	-0.028	0.036	0.032	-0.466***	-0.559***
	(0.039)	(0.044)	(0.024)	(0.032)	(0.048)	(0.075)
-13	0.063***	0.046*	0.051**	0.055**	-0.002	-0.088
	(0.024)	(0.027)	(0.022)	(0.026)	(0.063)	(0.079)
-12	0.069***	0.070***	0.063***	0.070***	-0.016	-0.062
	(0.022)	(0.024)	(0.020)	(0.023)	(0.048)	(0.058)
-11	0.084***	0.080***	0.080***	0.082***	-0.028	-0.038
	(0.020)	(0.022)	(0.020)	(0.021)	(0.044)	(0.055)
-10	0.047**	0.047**	0.048**	0.052**	-0.030	-0.017
	(0.019)	(0.022)	(0.020)	(0.022)	(0.040)	(0.055)
-9	0.050***	0.053***	0.035*	0.038**	0.010	0.018
	(0.019)	(0.021)	(0.018)	(0.019)	(0.036)	(0.047)
-8	0.051**	0.053**	0.035*	0.044**	0.033	0.010
	(0.020)	(0.021)	(0.020)	(0.020)	(0.038)	(0.045)
-7	0.045**	0.048**	0.047***	0.054***	0.005	-0.001
	(0.019)	(0.019)	(0.018)	(0.017)	(0.036)	(0.039)
-6	0.039**	0.047***	0.035**	0.043***	0.022	0.035
	(0.017)	(0.017)	(0.016)	(0.015)	(0.033)	(0.037)
-5	0.022	0.022	0.017	0.022	-0.003	-0.010
	(0.016)	(0.016)	(0.015)	(0.014)	(0.031)	(0.037)
-4	0.025	0.026	0.019	0.027*	0.020	-0.010
	(0.018)	(0.018)	(0.015)	(0.016)	(0.032)	(0.034)
-3	0.019	0.021	0.008	0.009	0.024	0.006
	(0.016)	(0.017)	(0.016)	(0.016)	(0.028)	(0.032)
-2	0.015	0.016	0.011	0.011	0.008	0.008
	(0.017)	(0.017)	(0.015)	(0.015)	(0.027)	(0.029)
0	0.030*	0.034**	0.026	0.026*	0.033	0.055**
	(0.017)	(0.016)	(0.016)	(0.016)	(0.025)	(0.026)
1	0.030*	0.039**	0.034*	0.036**	0.030	0.050*
	(0.018)	(0.018)	(0.018)	(0.018)	(0.026)	(0.028)
2	0.042**	0.048***	0.026	0.025	0.059**	0.075***
	(0.017)	(0.018)	(0.023)	(0.020)	(0.024)	(0.025)
3	0.048***	0.050***	0.068***	0.066***	0.064**	0.068**
	(0.017)	(0.017)	(0.022)	(0.021)	(0.025)	(0.028)
4	0.051**	0.050**	0.068***	0.062***	0.073**	0.087***
	(0.021)	(0.022)	(0.022)	(0.024)	(0.031)	(0.032)
5	0.025	0.024	0.096***	0.094***	0.046	0.045
	(0.022)	(0.023)	(0.027)	(0.028)	(0.029)	(0.030)
6	0.033	0.031	0.058**	0.056**	0.075**	0.064*
	(0.022)	(0.023)	(0.023)	(0.026)	(0.033)	(0.034)
7	-0.012	-0.010	0.031	0.022	0.032	0.027
	(0.024)	(0.026)	(0.025)	(0.027)	(0.037)	(0.039)
8	-0.011	-0.015	0.014	-0.001	0.053	0.057
	(0.024)	(0.026)	(0.024)	(0.027)	(0.039)	(0.041)
9	-0.029	-0.039	-0.010	-0.028	0.027	0.013
	(0.024)	(0.027)	(0.025)	(0.031)	(0.040)	(0.044)
10	-0.062**	-0.068**	0.007	-0.009	-0.007	0.021
	(0.031)	(0.034)	(0.030)	(0.040)	(0.050)	(0.053)
11	-0.076*	-0.081*	0.014	-0.034	-0.013	0.070
	(0.041)	(0.043)	(0.038)	(0.047)	(0.056)	(0.067)
12	-0.096	-0.102	0.067**	0.044	-0.016	0.034
	(0.074)	(0.080)	(0.026)	(0.028)	(0.085)	(0.098)
13	0.217*	0.193	0.069**	0.053*	0.345**	0.313*
	(0.114)	(0.125)	(0.029)	(0.030)	(0.147)	(0.174)
# of regions	190	190	128	128	62	62
N	2,850	2,850	1,920	1,920	930	930

Note. All regressions include the full vector of the control variables from Table 1.1. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.B10: Effects of second child policy on second births (2003-2017)

Relative time	Full sample		Sub-sample			
			Urban		Rural	
	Standard	IW	Standard	IW	Standard	IW
-14	-0.102	-0.133	-0.070	-0.099	-	-
	(0.063)	(0.097)	(0.057)	(0.089)		
-13	-0.104**	-0.150**	-0.070*	-0.090	-	-
	(0.044)	(0.070)	(0.040)	(0.064)		
-12	-0.109***	-0.122**	-0.101***	-0.106**	-0.209**	-0.139
	(0.040)	(0.049)	(0.037)	(0.051)	(0.099)	(0.093)
-11	-0.091***	-0.116**	-0.085***	-0.084*	-0.210**	-0.351***
	(0.032)	(0.046)	(0.031)	(0.048)	(0.095)	(0.095)
-10	-0.087***	-0.098**	-0.075***	-0.059	-0.233**	-0.301***
	(0.027)	(0.039)	(0.027)	(0.042)	(0.099)	(0.099)
-9	-0.088***	-0.094**	-0.086***	-0.079**	-0.153	-0.083
	(0.034)	(0.039)	(0.032)	(0.039)	(0.098)	(0.091)
-8	-0.056**	-0.050	-0.061***	-0.066**	-0.087	-0.005
	(0.027)	(0.033)	(0.023)	(0.030)	(0.068)	(0.063)
-7	-0.041*	-0.061**	-0.051**	-0.069***	-0.048	-0.051
	(0.022)	(0.029)	(0.021)	(0.027)	(0.045)	(0.034)
-6	-0.053***	-0.052*	-0.043**	-0.056*	-0.084*	-0.071*
	(0.021)	(0.029)	(0.020)	(0.030)	(0.043)	(0.040)
-5	-0.060***	-0.074***	-0.054***	-0.077***	-0.102***	-0.114***
	(0.017)	(0.027)	(0.016)	(0.026)	(0.038)	(0.040)
-4	-0.041***	-0.043**	-0.049***	-0.059***	-0.054*	-0.040
	(0.015)	(0.021)	(0.016)	(0.021)	(0.033)	(0.033)
-3	-0.027**	-0.027	-0.028**	-0.034*	-0.042	-0.052
	(0.014)	(0.018)	(0.014)	(0.018)	(0.028)	(0.032)
-2	-0.010	-0.004	-0.007	-0.009	-0.027	0.000
	(0.013)	(0.015)	(0.013)	(0.015)	(0.029)	(0.029)
0	0.019	0.028*	0.017	0.030**	0.034	0.052**
	(0.013)	(0.014)	(0.013)	(0.014)	(0.027)	(0.026)
1	0.050***	0.058***	0.033***	0.044***	0.091***	0.124***
	(0.013)	(0.014)	(0.013)	(0.014)	(0.028)	(0.026)
2	0.062***	0.077***	0.048***	0.063***	0.098***	0.117***
	(0.015)	(0.017)	(0.014)	(0.016)	(0.032)	(0.029)
3	0.090***	0.101***	0.070***	0.075***	0.143***	0.170***
	(0.016)	(0.017)	(0.014)	(0.016)	(0.034)	(0.029)
4	0.090***	0.106***	0.057***	0.064***	0.164***	0.174***
	(0.017)	(0.018)	(0.016)	(0.017)	(0.036)	(0.029)
5	0.078***	0.087***	0.057***	0.049***	0.144***	0.178***
	(0.019)	(0.020)	(0.017)	(0.019)	(0.041)	(0.032)
6	0.077***	0.087***	0.050***	0.038*	0.152***	0.192***
	(0.021)	(0.022)	(0.019)	(0.020)	(0.045)	(0.035)
7	0.107***	0.116***	0.077***	0.066***	0.190***	0.244***
	(0.024)	(0.026)	(0.022)	(0.024)	(0.051)	(0.043)
8	0.096***	0.110***	0.067***	0.058**	0.182***	0.238***
	(0.027)	(0.028)	(0.025)	(0.026)	(0.054)	(0.046)
9	0.080***	0.084***	0.049*	0.037	0.189***	0.245***
	(0.029)	(0.032)	(0.027)	(0.028)	(0.062)	(0.054)
10	0.048	0.059	0.030	0.033	0.167**	0.218***
	(0.031)	(0.036)	(0.028)	(0.032)	(0.072)	(0.063)
11	0.037	0.047	0.013	0.000	0.167**	0.260***
	(0.037)	(0.047)	(0.035)	(0.043)	(0.084)	(0.081)
12	0.077	0.059	0.040	0.007	0.239**	0.281***
	(0.047)	(0.063)	(0.044)	(0.059)	(0.093)	(0.082)
13	0.125	0.106	0.079**	0.116	0.280	0.074
	(0.080)	(0.103)	(0.036)	(0.084)	(0.192)	(0.190)
# of regions	193	193	129	129	64	64
N	2,895	2,895	1,935	1,935	960	960

Note. All regressions include the full vector of the control variables from Table 1.1. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.B11: Effects of third child policy on third+ births (2003-2011)

Relative time	Full sample		Sub-sample			
			Urban		Rural	
	Standard	IW	Standard	IW	Standard	IW
-8	-0.001	-0.054	0.078	0.096	-0.019	-0.207*
	(0.059)	(0.089)	(0.049)	(0.069)	(0.118)	(0.125)
-7	0.003	0.037	0.052	0.093**	-0.026	0.007
	(0.056)	(0.067)	(0.038)	(0.047)	(0.134)	(0.171)
-6	0.034	0.000	0.101***	0.076	-0.045	-0.094
	(0.039)	(0.056)	(0.031)	(0.049)	(0.081)	(0.093)
-5	0.031	-0.002	0.060**	0.074**	0.076	-0.087
	(0.033)	(0.046)	(0.025)	(0.033)	(0.081)	(0.091)
-4	0.040	0.061	0.065***	0.085***	0.067	0.071
	(0.025)	(0.038)	(0.020)	(0.026)	(0.058)	(0.062)
-3	0.015	0.038	0.043***	0.066***	-0.004	0.054
	(0.020)	(0.027)	(0.016)	(0.020)	(0.048)	(0.068)
-2	0.013	0.005	0.013	0.017	0.038	-0.006
	(0.015)	(0.019)	(0.013)	(0.014)	(0.041)	(0.046)
0	0.007	0.002	-0.010	-0.009	0.026	0.047
	(0.017)	(0.018)	(0.015)	(0.016)	(0.039)	(0.045)
1	0.010	0.007	-0.032**	-0.023	0.055	0.007
	(0.018)	(0.020)	(0.015)	(0.017)	(0.043)	(0.058)
2	-0.003	0.000	-0.043**	-0.028	0.023	0.017
	(0.024)	(0.023)	(0.018)	(0.022)	(0.054)	(0.053)
3	0.005	0.014	-0.050**	-0.027	0.053	0.041
	(0.030)	(0.031)	(0.023)	(0.027)	(0.064)	(0.070)
4	0.007	0.017	-0.040	-0.020	0.020	-0.007
	(0.037)	(0.036)	(0.028)	(0.030)	(0.076)	(0.075)
5	-0.007	-0.024	-0.065*	-0.059*	0.034	-0.014
	(0.045)	(0.045)	(0.034)	(0.033)	(0.093)	(0.095)
6	-0.038	-0.106*	-0.099**	-0.146***	0.009	-0.085
	(0.054)	(0.062)	(0.043)	(0.041)	(0.106)	(0.136)
7	0.001	0.091	-0.008	0.002	-0.109	0.103
	(0.105)	(0.129)	(0.091)	(0.108)	(0.201)	(0.219)
# of regions	198	198	134	134	64	64
N	1,782	1,782	1,206	1,206	576	576

Note. All regressions include the full vector of the control variables from Table 1.1. Robust standard errors in parentheses clustered at the level of local government. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1.B12: Confidence sets: the effects of the first child policy (2003-2017)

Post-period	Original (*IW*)		FLCI	
	LB	UB	LB	UB
0	0.001	0.066	-0.001	0.059
1	0.003	0.074	0.004	0.069
2	0.013	0.083	0.022	0.085
3	0.016	0.084	0.035	0.095
4	0.008	0.093	0.031	0.110
5	-0.020	0.069	0.007	0.091
6	-0.015	0.077	0.017	0.105
7	-0.061	0.041	-0.023	0.076
8	-0.065	0.035	-0.023	0.077
9	-0.092	0.014	-0.045	0.061
10	-0.134	-0.001	-0.084	0.051
11	-0.166	0.004	-0.112	0.060
12	-0.258	0.054	-0.200	0.116
13	-0.053	0.439	0.004	0.502

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B13: Confidence sets: the effects of the first child policy (2003-2017): Urban and rural areas

Post-period	Urban area				Rural area			
	Original (*IW*)		FLCI		Original (*IW*)		FLCI	
	LB	UB	LB	UB	LB	UB	LB	UB
0	-0.005	0.056	-0.000	0.053	0.005	0.105	-0.006	0.091
1	0.001	0.071	0.009	0.070	-0.005	0.104	-0.022	0.089
2	-0.014	0.063	0.001	0.068	0.026	0.125	0.001	0.103
3	0.025	0.107	0.050	0.119	0.014	0.122	-0.001	0.105
4	0.016	0.109	0.047	0.127	0.023	0.150	0.005	0.132
5	0.040	0.149	0.076	0.172	-0.013	0.104	-0.039	0.087
6	0.005	0.108	0.049	0.137	-0.003	0.131	-0.028	0.117
7	-0.031	0.074	0.022	0.114	-0.050	0.103	-0.077	0.084
8	-0.053	0.052	0.009	0.098	-0.023	0.137	-0.057	0.118
9	-0.088	0.032	-0.021	0.085	-0.073	0.100	-0.106	0.081
10	-0.088	0.070	-0.014	0.125	-0.082	0.124	-0.129	0.090
11	-0.125	0.057	-0.053	0.134	-0.062	0.201	-0.123	0.164
12	-0.010	0.099	0.060	0.164	-0.158	0.226	-0.225	0.183
13	-0.006	0.112	0.061	0.195	-0.029	0.654	-0.082	0.615

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B14: Confidence sets: the effects of the second child policy (2003-2017)

Post-period	Original (*IW*)		FLCI	
	LB	UB	LB	UB
0	-0.000	0.055	-0.010	0.035
1	0.030	0.086	0.009	0.054
2	0.044	0.109	0.010	0.064
3	0.067	0.135	0.022	0.081
4	0.070	0.141	0.013	0.078
5	0.048	0.126	-0.020	0.053
6	0.045	0.130	-0.039	0.050
7	0.065	0.168	-0.024	0.071
8	0.055	0.165	-0.052	0.061
9	0.021	0.147	-0.096	0.017
10	-0.012	0.129	-0.149	-0.012
11	-0.046	0.139	-0.195	-0.028
12	-0.065	0.183	-0.224	-0.002
13	-0.096	0.308	-0.231	0.176

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B15: Confidence sets: the effects of the second child policy (2003-2017): Urban and rural areas

Post-period	Urban area				Rural area			
	Original (*IW*)		FLCI		Original (*IW*)		FLCI	
	LB	UB	LB	UB	LB	UB	LB	UB
0	0.003	0.057	-0.007	0.040	0.002	0.102	0.009	0.096
1	0.017	0.071	-0.002	0.045	0.073	0.175	0.069	0.163
2	0.032	0.094	-0.001	0.057	0.061	0.173	0.038	0.153
3	0.044	0.107	0.001	0.064	0.113	0.227	0.076	0.200
4	0.032	0.097	-0.024	0.047	0.117	0.231	0.067	0.201
5	0.012	0.086	-0.055	0.028	0.115	0.241	0.052	0.202
6	-0.002	0.077	-0.085	0.012	0.122	0.261	0.047	0.216
7	0.019	0.113	-0.070	0.034	0.160	0.327	0.076	0.268
8	0.006	0.110	-0.104	0.021	0.148	0.329	0.049	0.265
9	-0.018	0.093	-0.142	-0.015	0.138	0.352	0.017	0.259
10	-0.030	0.097	-0.173	-0.028	0.095	0.341	-0.045	0.229
11	-0.083	0.084	-0.244	-0.067	0.101	0.419	-0.038	0.296
12	-0.110	0.123	-0.279	-0.053	0.12	0.442	-0.053	0.303
13	-0.049	0.281	-0.200	0.135	-0.298	0.445	-0.462	0.313

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B16: Confidence sets: the effects of the third child policy (2003-2011)

Post-period	Original (*IW*)		FLCI	
	LB	UB	LB	UB
0	-0.033	0.036	-0.027	0.037
1	-0.031	0.046	-0.022	0.045
2	-0.045	0.045	-0.044	0.054
3	-0.047	0.074	-0.047	0.077
4	-0.055	0.088	-0.062	0.113
5	-0.112	0.065	-0.087	0.122
6	-0.228	0.016	-0.176	0.103
7	-0.161	0.343	-0.123	0.375

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B17: Confidence sets: the effects of the third child policy (2003-2011): Urban and rural areas

Post-period	Urban area				Rural area			
	Original (*IW*)		FLCI		Original (*IW*)		FLCI	
	LB	UB	LB	UB	LB	UB	LB	UB
0	-0.040	0.022	-0.019	0.040	-0.041	0.135	-0.039	0.121
1	-0.056	0.010	-0.024	0.035	-0.106	0.121	-0.098	0.097
2	-0.070	0.015	-0.022	0.055	-0.087	0.12 0	-0.122	0.101
3	-0.080	0.027	-0.018	0.080	-0.096	0.179	-0.134	0.126
4	-0.079	0.040	-0.005	0.118	-0.154	0.14 0	-0.241	0.121
5	-0.125	0.006	-0.026	0.133	-0.200	0.173	-0.207	0.149
6	-0.226	-0.066	-0.097	0.104	-0.350	0.181	-0.364	0.188
7	-0.209	0.213	-0.031	0.395	-0.326	0.532	-0.456	0.487

Note. "LB" and "UB" represent lower bound and upper bound, respectively.

Table 1.B18: Total subsidies paid and the estimated number of increased births (detailed)

Post period	First			Second			Third+		
	LB	UB	Subsidies paid ($)	LB	UB	Subsidies paid ($)	LB	UB	Subsidies paid ($)
0	-54	3,186	19,446,992	-1,251	4,379	70,199,230	-980	1,343	47,919,032
1	186	3,204	15,128,172	1,088	6,530	69,471,378	-761	1,557	55,892,181
2	903	3,488	15,654,013	1,195	7,651	86,697,875	-1,497	1,838	67,753,962
3	1,304	3,540	15,287,709	2,569	9,458	88,572,726	-1,440	2,360	68,928,488
4	1,122	3,980	14,352,474	1,518	9,107	81,178,355	-1,574	2,868	61,258,482
5	246	3,194	12,819,316	-2,321	6,151	81,082,762	-1,374	1,927	39,110,642
6	569	3,515	12,949,804	-4,337	5,560	80,972,814	-1,489	871	21,860,233
7	-683	2,257	10,635,930	-2,352	6,958	71,281,514	-185	564	3,816,239
8	-633	2,121	9,657,417	-4,770	5,596	62,862,554			
9	-1,142	1,548	7,939,390	-6,272	1,111	40,221,285			
10	-1,633	991	6,947,780	-8,284	-667	35,884,140			
11	-1,452	778	4,865,896	-6,641	-954	19,601,434			
12	-1,620	940	3,072,762	-4,515	-40	10,749,544			
13	9	1,084	1,764,401	-1,124	856	3,890,112			

Note. Total subsidies paid are calculated by applying the exchange rate of 2017 provided by the Bank of Korea, which is $1 = 1,130.84 won. Lower (upper) bound of the increase in the estimated number of births for each post-period is calculated as the average births in reference year * lower (upper) bound of policy effect in the corresponding post-period* the number of local governments in the same post-period. Subsidies paid for each post-period is calculated as the average of first (second, third) births in the corresponding post-period * the average of the subsidies for the first (second, third) births in the same post-period * the number of local governments in the same post-period.

Table 1.B19: The year of introduction of childbirth subsidy policies by metropolitan governments

Metropolitan area	Policy introduction	First	Second	Third+
Seoul	X	-	-	-
Busan	O	-	2009	2006
Daegu	O	-	2008	2007
Incheon	O	2018	2012	2011
Gwangju	O	2017	2011	2009
Daejeon	O	2019	2012	2008
Ulsan	O	-	2016	2008
Sejong	O	2014	2014	2014
Gyeonggi-do	X	-	-	-
Gangwon-do	O	2019	2019	2019
Chungcheongbuk-do	O	-	2007	2007
Chungcheongnam-do	O	2018	2018	2018
Jeollabuk-do	X	-	-	-
Jeollanam-do	O	2001	2001	2001
Gyeongsangbuk-do	O	2016	2012	2007
Gyeongsangnam-do	O	-	-	2005
Jeju	O	2012	2009	2007

Note. 228 local governments and 17 metropolitan governments.

*Note.*The Incheon metropolitan government started a childbirth subsidy for second births in 2008 but stopped paying the childbirth subsidy during the period 2015–2017. Also, Incheon began childbirth subsidies for third or subsequent births in 2011 but stopped paying the childbirth subsidies in 2016 and 2017. In 2018, the Incheon metropolitan government restarted its policy of childbirth subsidies for all birth orders.

Table 1.B20: The year of the introduction of childbirth subsidy policy by local government

Metropolitan City/Province	Local Municipality	First	Second	Third+
Seoul	Jongro-Gu	-	2008	2008
	Jung-Gu	2017	2007	2007
	Yongsan-Gu	2008	2008	2008
	Seongdong-Gu	- (2007)	2007	2007
	Gwang-jin-Gu	-	2008	2008
	Dongdaemun-Gu	-	2008	2008
	Jungnang-Gu	-	2009	2009
	Seongbuk-Gu	-	2008	2008
	Gangbuk-Gu	- (2007-2010)	2007	2007
	Dobong-Gu	- (2009-2010)	2009	2009
	Nowon-Gu	-	2008	2008
	Eun-pyeong-Gu	-	2009	2009
	Seodaemun-Gu	2009	2009	2009
	Mapo-Gu	2010	2010	2010
	Yangcheon-Gu	- (2006)	2006	2006
	Gangseo-Gu	-	2016	2008
	Guro-Gu	-	2010	2010
	Geum-cheon-Gu	-	2008	2008
	Yeongdeungpo-Gu	-	2010	2008
	Dongjak-Gu	-	2010	2010
	Gwanak-Gu	-	2008	2008
	Seocho-Gu	- (2007-2016)	2007	2007
	Gangnam-Gu	- (2009)	2007	2007
	Songpa-Gu	-	2009	2009
	Gangdong-Gu	2017	2009	2009
Busan	Jung-Gu	-	2007	2007
	Seo-Gu	-	2009	2006
	Dong-Gu	-	2009	2006
	Yeongdo-Gu	-	2008	2006
	Busanjin-Gu	-	2009	2006
	Dongnae-Gu	-	2009	2006
	Nam-Gu	-	2009	2006
	Buk-Gu	-	2009	2006
	Haeundae-Gu	-	2009	2006
	Saha-Gu	-	2009	2006
	Geumjeong-Gu	2017	2009	2006

Busan	Gangseo-Gu	-	2009	2006
	Yeonje-Gu	-	2009	2006
	Suyeong-Gu	-	2009	2006
	Sasang-Gu	-	2009	2006
	Gijang-Gun	-	2009	2006
Daegu	Jung-Gu	2015	2009	2007
	Dong-Gu	-	2009	2007
	Seo-Gu	-	2009	2007
	Nam-Gu	-	2009	2007
	Buk-Gu	-	2009	2007
	Suseong-Gu	-	2009	2007
	Dalseo-Gu	-	2009	2007
	Dalseong-Gun	2011	2009	2007
Incheon	Jung-Gu	-	- (2010, 2014)	2007
	Dong-Gu	2015	2012	2011
	Michuhol-Gu	-	- (2012-2014)	2011
	Yeonsu-Gu	-	- (2012-2014, 2017)	2009
	Namdong-Gu	-	- (2012-2014)	- (2009-2015)
	Bupyeong-Gu	-	- (2012-2015)	- (2009-2015)
	Gyeyang-Gu	2016	- (2012-2014, 2016-2017)	2009
	Seo-Gu	- (2011)	- (2011-2014)	- (2009-2015)
	Ganghwa-Gun	2005	2005	2005
	Ongjin-Gun	2006	2006	2006
Gwangju	Dong-Gu	-(2009-2014, 2017-2018)	2009	2007
	Seo-Gu	2017	2011	2009
	Nam-Gu	2017	2011	2009
	Buk-Gu	2017	2011	2009
	Gwangsan-Gu	2017	2011	2009
Daejeon	Dong-Gu	-	2011	2008
	Jung-Gu	-	2011	2008
	Seo-Gu	2016	2011	2008
	Yuseong-Gu	-	2011	2008
	Daedeok-Gu	2015	2011	2008
Ulsan	Jung-Gu	-	2009	2007
	Nam-Gu	-	2011	2008
	Dong-Gu	-	2009	2008
	Buk-Gu	-	2010	2008
	Ulju-Gun	2011	2011	2008

Gyeonggi-do	Suwon-Si	-	2017	2008
	Seongnam-Si	-	2010	2008
	Uijeongbu-Si	-	-	2011
	Anyang-Si	-	2015	2008
	Bucheon-Si	-	2017	2008
	Gwangmyeong-Si	-	2016	2007
	Pyeongtaek-Si	-	2006	2006
	Dongducheon-Si	-	2007	2007
	Ansan-Si	-	2017	2006
	Goyang-Si	-	-	2005
	Gwacheon-Si	-	2007	2007
	Guri-Si	-	2004	2004
	Namyangju-Si	-	2007	2007
	Osan-Si	-	2012	2007
	Siheung-Si	-	2009	2009
	Gunpo-Si	2017	2006	2006
	Uiwang-Si	-	2005	2005
	Hanam-Si	-	2017	2009
	Yongin-Si	-	2007	2007
	Paju-Si	-	-	2005
	Icheon-Si	-	-	2004
	Anseong-Si	-	-	2012
	Gimpo-Si	2012	2012	2007
	Hwaseong-Si	-	- (2006-2010)	2006
	Gwangju-Si	-	-	2009
	Yangju-Si	-	2006	2006
	Pocheon-Si	-	2009	2009
	Yeoju-Si	2017	2011	2008
	Yeoncheon-Gun	2006	2006	2006
	Gapyeong-Gun	-	2010	2006
	Yangpyeong-Gun	2017	2011	2011
Gangwon-do	Chuncheon-Si	2017	2017	2017
	Wonju-Si	2011	2011	2011
	Gangneung-Si	2006	2006	2006
	Donghae-Si	-	2005	2005
	Taebaek-Si	-	2007	2007
	Sokcho-Si	-	2006	2006
	Samcheok-Si	2017	2005	2005
	Hongcheon-Gun	-	2011	2011

Gangwon-do	Hoengseong-Gun	2011	2011	2011
	Yeongwol-Gun	2006	2006	2006
	Pyeongchang-Gun	2012	2012	2012
	Jeongseon-Gun	-	2011	2008
	Cheorwon-Gun	-	2007	2007
	Hwacheon-Gun	-	-	2009
	Yanggu-Gun	-	2015	2008
	Inje-Gun	2011	2011	2011
	Goseong-Gun	2005	2005	2005
	Yangyang-Gun	2007	2007	2007
Chungcheong buk-do	Chungju-Si	2008	2007	2007
	Jecheon-Si	2008	2007	2007
	Boeun-Gun	2009	2007	2007
	Okcheon-Gun	2008	2007	2007
	Yeongdong-Gun	2004	2004	2004
	Jeungpyeong-Gun	2012	2012	2007
	Jincheon-Gun	2007	2007	2007
	Goesan-Gun	2005	2005	2005
	Eumseong-Gun	2008	2007	2007
	Danyang-Gun	2007	2007	2007
Chungcheong nam-do	Dangjin-Si	2007	2005	2005
	Cheonan-Si	-	-	2005
	Gongju-Si	2014	2005	2005
	Boryeong-Si	2015	2005	2005
	Asan-Si	-	2006	2006
	Seosan-Si	2004	2004	2004
	Nonsan-Si	2007	2007	2007
	Gyeryong-Si	2011	2004	2004
	Geumsan-Gun	2007	2007	2007
	Buyeo-Gun	2011	2005	2005
	Seocheon-Gun	2005	2005	2005
	Cheongyang-Gun	2004	2004	2004
	Hongseong-Gun	- (2006-2008)	2006	2006
	Yesan-Gun	2015	2015	2015
	Taean-Gun	2005	2005	2005
Jeolla buk-do	Jeonju-Si	-	2015	2011
	Gunsan-Si	2013	2013	2013
	Iksan-Si	2017	2004	2004
	Jeongeup-Si	2017	2005	2005
	Namwon-Si	2010	2006	2006

Jeolla buk-do	Gimje-Si	- (2005-2011)	2005	2005
	Wanju-Gun	2015	2009	2009
	Jinan-Gun	2006	2006	2006
	Muju-Gun	2005	2005	2005
	Jangsu-Gun	2008	2008	2008
	Imsil-Gun	2008	2008	2008
	Sunchang-Gun	2004	2004	2004
	Gochang-Gun	- (2006, 2017)	2006	2005
	Buan-Gun	2016	2010	2007
Jeolla nam-do	Mokpo-Si	2008	2007	2005
	Yeosu-Si	2011	2011	2006
	Suncheon-Si	2011	2011	2007
	Naju-Si	2010	2010	2005
	Gwangyang-Si	2008	2008	2008
	Damyang-Gun	2001	2001	2001
	Gokseong-Gun	2001	2001	2001
	Gurye-Gun	2001	2001	2001
	Goheung-Gun	2001	2001	2001
	Boseong-Gun	2001	2001	2001
	Hwasun-Gun	2001	2001	2001
	Jangheung-Gun	2001	2001	2001
	Gangjin-Gun	2001	2001	2001
	Haenam-Gun	2001	2001	2001
	Yeongam-Gun	2001	2001	2001
	Muan-Gun	2001	2001	2001
	Hampyeong-Gun	2001	2001	2001
	Yeonggwang-Gun	2001	2001	2001
	Jangseong-Gun	2001	2001	2001
	Wando-Gun	2001	2001	2001
	Jindo-Gun	2001	2001	2001
	Sinan-Gun	2001	2001	2001
Gyeongsang buk-do	Pohang-Si	2013	2012	2007
	Gyeongju-Si	2016	2007	2007
	Gimcheon-Si	2006	2006	2006
	Andong-Si	2006	2006	2006
	Gumi-Si	2016	2012	2007
	Yeongju-Si	2006	2006	2006
	Yeongcheon-Si	2007	2007	2007
	Sangju-Si	2006	2006	2006
	Mungyeong-Si	2007	2007	2007

Gyeongsang buk-do	Gyeongsan-Si	2008	2008	2006
	Gunwi-Gun	2001	2001	2001
	Uiseong-Gun	2008	2008	2007
	Cheongsong-Gun	2009	2009	2007
	Yeongyang-Gun	2005	2005	2005
	Yeongdeok-Gun	2007	2007	2007
	Cheongdo-Gun	2007	2007	2007
	Goryeong-Gun	2009	2009	2007
	Seongju-Gun	2005	2005	2005
	Chilgok-Gun	2016	2007	2007
	Yecheon-Gun	2016	2009	2005
	Bonghwa-Gun	2005	2005	2005
	Uljin-Gun	2016	2007	2007
	Ulleung-Gun	2005	2005	2005
Gyeongsang nam-do	Jinju-Si	-	2005	2005
	Tongyeong-Si	-	-	2005
	Sacheon-Si	-	2011	2006
	Gimhae-Si	-	-	2005
	Miryang-Si	2014	2005	2005
	Geoje-Si	-	-	2005
	Yangsan-Si	2017	2017	2005
	Uiryeong-Gun	2005	2005	2005
	Haman-Gun	2010	2006	2005
	Changnyeong-Gun	2008	2005	2005
	Goseong-Gun	2016	2007	2007
	Namhae-Gun	-	2006	2005
	Hadong-Gun	2015	2009	2005
	Sancheong-Gun	2010	2010	2005
	Hamyang-Gun	2008	2008	2005
	Geochang-Gun	-	2007	2007
	Hapcheon-Gun	2007	2007	2007

Data. 228 local governments and 17 metropolitan governments.
Note. "-" means that local governments had not yet introduced a childbirth subsidy policy as of 2017 or had implemented the policy in the past. I exclueded Sejong Metropolitan Autonomous City and Jeju Special Self-Governing Province because they have different characteristics from other Cities and Provinces.

Chapter 2

Impact of Older Workers on Employment Status and Fertility Rate among Younger Workers

2.1 Introduction

Over the past few decades, while many countries have experienced low birth rate, the United States has avoided this problem, showing a relatively stable total fertility rate (TFR) around the population replacement rate of 2.1. However, both TFR and the total number of births in the United States have been decreasing since 2007.[1] Looking at fertility rate by age group,[2] three age groups (i.e., 15–19, 20–24, and 25–29) account for this change. The sharp decline in fertility among teens aged 15–19 is partly attributable to the decline in unintended births, as Buckles et al.(2019) documented. However, the ongoing decline in fertility among the age groups 20–24 and 25–29 needs further explanation.

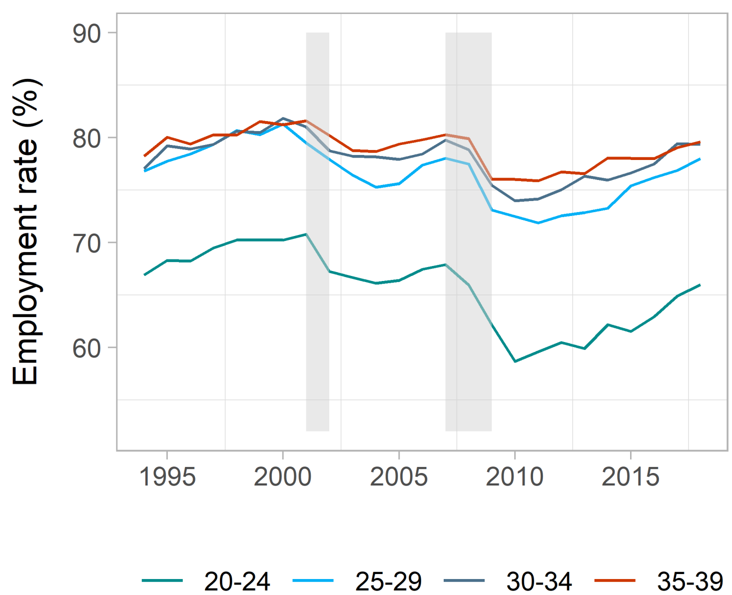
To explore possible causes of the decline in fertility, I focused on the labor market in the 2000s. A striking feature observed in the United States labor market since 2000 is the deterioration in employment of young adults, especially those who recently graduated from college (Abel et al., 2014; Beaudry et al., 2014). Since Becker (1960) proposed his economic model of fertility, many scholars have attempted to explain declines in fertility (e.g., rising opportunity cost of childbirth due to an increase in women's educational opportunities, the household bargaining model), but existing models do not account for income as a main variable of interest. According to neoclassical fertility theory, income level is fundamentally related to fertility; therefore, the employment status of

[1] See Appendix, Figure 2.B1.
[2] See Appendix, Figure 2.B2.

young adults could provide a simple explanation for their decline in childbirth.

As shown in Figure 2.1, the employment rate among young adults essentially depends on economic fluctuations. However, even taking into account the changes due to the business cycle, the post-2000 employment rate has decreased for age groups 20–24 and 25–29. This decline is particularly noticeable for young adults aged 20–24, which is the same group with a striking decline in fertility rate during the same periods.

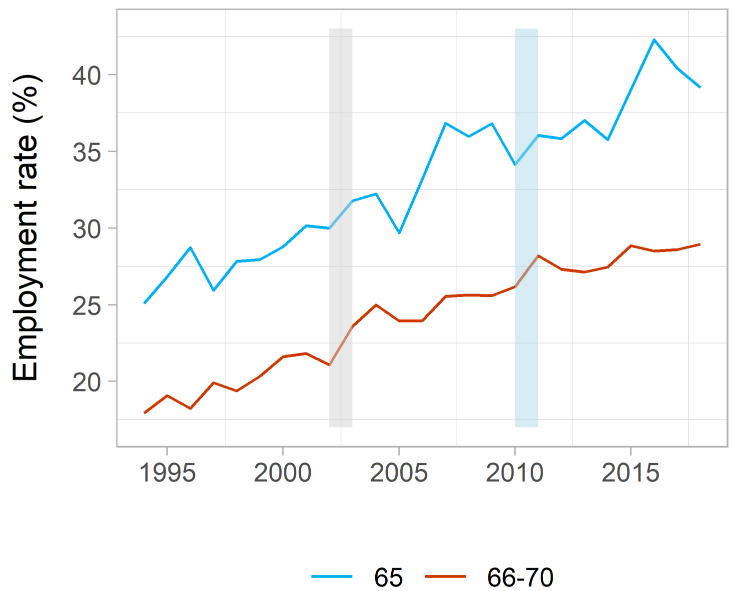
Figure 2.1: Employment rate of young adults by age group



Data. 1994–2018 Annual Social and Economic Supplement of the Current Population Survey.
Note. The employment rate is the ratio of the number of people employed to the population. Individuals are weighted using personal weights provided by data sources. The shaded vertical bars represent the recession in 2001 and the Great Recession in 2008, respectively.

Another critical feature found in the labor market is a significant increase in older workers (Gustman and Steinmeier, 2009). As shown in Figure 2.2, the employment rate of those aged 66–70 has steadily increased. The following factors might cause older workers to want to stay in the labor market longer: (a) changes in retirement incentives caused by social security reform (Coile and Gruber, 2007; Hurd, 1990; Ruhm, 1995), (b) increased life expectancy (Echevarría and Iza, 2006; Prettner and Canning, 2014; Van Solinge and Henkens, 2010), and (c) expansion of less physically demanding jobs (Acemoglu and Autor, 2011). The actual data show the possibility that changes in the social security system affect retirement decisions.

Figure 2.2: Employment rate of people aged 65 and 66–70



Data. 1994–2018 Annual Social and Economic Supplement of the Current Population Survey.
Note. The employment rate is the ratio of the number of people employed to the population. Individuals are weighted using personal weights provided by data sources. The grey shaded area marks a change in social security policy that increased FRA from 65 years to 65 years and two months in 2003. The blue shaded area marks the year 2011, when the first cohort of Baby Boomers reached age 65.

2003 was the year when the Full Retirement Age (FRA), the age of eligibility for claiming full retirement benefits, increased from 65 years to 65 years and 2 months. Thus, potential retirees are likely to stay in the labor market for up to 2 extra months to claim full benefits rather than leave the labor market before that time. In fact, as shown in Figure 2.2, the employment rate of those aged 65 increased significantly in 2003 (gray shaded area). In addition, 2011 was the year when the first cohort of Baby Boomers reached age 65, driving a substantial increase in the employment rate of 65-year-olds between 2010 and 2011 (blue shaded area). The employment rate of those aged 65 and 66–70 has increased since 2011, indicating that a large percentage of Baby Boomers continue working beyond FRA. Considering that Baby Boomers constitute a larger population than the previous generation, known as the Silent Generation, the number of older people in the labor market has steadily increased as well.

The time when both TFR and the number of total births started to decrease coincides with the social security reform that extended FRA and the approaching retirement age for Baby Boomers. Based on these facts, I proposed the following hypothesis:

> **Hypothesis:** Delayed retirement among the elderly whose age is beyond the FRA deteriorates young adults' employment in terms of quantity and quality, and thus eventually their fertility.

To test this hypothesis, I divided labor force participation into five categories using the Current Population Survey (CPS) supplemental data: (a) full-time employment, (b) part-time employment for economic reasons,[3] (c) part-time employment for noneconomic reasons,[4] (d) unemployment, and (e) not in the labor force. With these five mediators, I first examined how elderly workers affected the employment status of young adults. Then I estimated how each change in employment status affected the fertility rate of young adults. Based on the two sets of results, I extracted valid pathways showing that an increase in the number of older workers affected fertility rate.

First, I found that an increase in elderly workers aged 66–70 hurt the labor market outcomes of young adults aged 20–29 by decreasing their full-time employment and increasing their part-time employment for economic reasons. At the same time, the employment status of young adults aged 30 to 39 remained unaffected. The fact that young adults aged 20–29 was affected by the employment rate of elderly was consistent for men and women even though the components of employment status affected by elderly employment differed between men and women. Second, although the estimated impacts were tiny, I also found a decline in the quality of labor market outcomes of young adults aged 20–24 due to the extension of retirement timing at the state level. Third, I found

[3] The Bureau of Labor Statistics (BLS) defines part-time workers for economic reasons as people who work part-time but want and are available for full-time work. In other words, it refers to those who were able to work full-time but work part-time because they could not find a full-time job.

[4] Unlike part-time workers for economic reasons, this category includes only people who work part-time because they do not want to work full-time or are unavailable for full-time work.

that job instability measured by part-time employment for economic reasons and unemployment had a negative impact on fertility, while full-time employment increased fertility. However, when analyzing men and women separately, I found that full-time employment of women aged 25–29 decreased childbirth.

From the two sets of results, I found two pathways showing that the postponement of retirement among the elderly reduced fertility among young adults. Specifically, a one percentage point increase in older workers aged 66–70 decreased fertility by 0.8 conceptions per 1,000 for young adults aged 20–24 by decreasing their full-time employment and increasing their part-time employment for economic reasons. This one percentage point increase also decreased fertility by 0.6 conceptions per 1,000 for young adults aged 25–29 by raising their part-time employment for economic reasons. Based on the results by marital status, a one percentage point increase in older workers aged 66–70 decreased fertility by 3.2 conceptions per 1,000 married young adults aged 20–24 by decreasing their full-time employment and increasing their part-time employment for economic reasons. Fertility among unmarried women decreased by 0.4 conceptions due to the decline in full-time employment caused by a one percentage point increase in the older working population.

The findings of this study make three contributions. First, the findings show that the decline in fertility among age groups 20–24 and 25–29 in the United States since the mid-2000s could be partly explained by the increase in elderly employment. Specifically, the reduction in fertility due to delayed retirement accounts for 20% of the total reduction in births of young adults aged 20–24 and 40% of that of young adults aged 25–29 during the period 1994–2018. These results question whether pension reform that limits retirement benefits to keep older workers in the labor market longer is desirable in countries facing low birth rate and aging population issues at the same time.

Second, the findings shed light on the substitutionary relationship between older workers and younger workers. Considering that many countries have increased the legal retirement age or the age at which retirees can receive social pension benefits, the relevant age of older workers, when examining their relationship to younger workers, is no longer 55–64. Hence, in this paper, older workers are defined as those aged 66–70, allowing me to draw implications for social security reforms. Besides, the findings show that interpreting the relationship between older and younger workers based only on the employment rate (i.e., the ratio of the numbers of people employed regardless of full-time and part-time) is insufficient. In other words, older workers once had a relatively small negative impact on the number of employed young adults. With this result, one might think the impact of older workers on the employment of younger workers is not large enough to cause concern. However, the increase in elderly workers has lowered the quality of employment among young adults by decreasing their full-time employment and increasing their part-time employment for economic reasons. These results suggest that delayed retirement of the elderly threatens job security of the young and lowers the income level of younger workers. This fact implies that the qualitative aspect of employment should be considered when investigating the substitutionary relationship between older workers and younger workers.

Third, this paper contributed to our understanding of how all economic activity statuses of young adults affect their fertility, while many studies confined their research interest to the effect of unemployment on fertility (Adserà, 2004; Cazzola et al., 2016; Butz and Ward, 1979; Currie and Schwandt, 2014). I found that the negative impact of part-time employment for economic reasons on fertility was greater than unemployment. This finding indicates that the current decline in fertility rate could continue if the employment status of young adults (i.e., borderline between employment and unemployment) does not improve.

The remainder of the paper is organized as follows. Section 2.2 briefly summarizes previous literature in three relevant areas. Section 2.3 introduces the data, and Section 2.4 describes the empirical results. Section 2.5 presents the robustness check. Section 2.6 discusses policy implications based on the results, and Section 2.7 summarizes the findings.

2.2 Literature Review

2.2.1 The relationship between older and younger workers

Whether older workers are plausible substitutes for younger workers is a long-standing concern. This discussion closely relates to government policy, the focus of which has shifted little by little over time. In the 1970s and 1980s, policymakers among countries experiencing higher unemployment of young adults tried to determine whether work sharing might reduce youth unemployment (Dreze, 1986; Riechel, 1986).

Since the 1990s, scholars have conducted studies on the relationship between older and younger workers due to concerns about the sustainability of social security. With the combination of prevalent early retirement and low birth rate, the issue of the financial depletion of social pensions emerged for the first time. This problem led to the argument that pension reform was necessary to reduce incentives for early retirement. Because the social pension system plays a crucial role in determining when potential retirees leave the labor market (Hurd, 1990; Ruhm, 1995), an important question related to social pension reform is how older workers affect employment of younger workers. At that time, the idea that early retirement creates more opportunities for younger workers was prevalent. People concerned about the financial risk of social pensions believed that this idea hindered pension reform (Kalwij et al., 2010).

The book *Social Security Programs and Retirement around the World: The Relationship to Youth Employment* (Gruber and Milligan, 2010) features analysis of the relationship between older and younger workers in twelve countries.[5] Most scholars involved in this book did not have evidence that early retirement gave younger workers more opportunities to work in many countries. However, the United States yielded evidence that older workers crowded out younger workers (Gruber and Milligan, 2010).

Indeed, many scholars have not found a substitutionary relationship between older and younger workers (Bertoni and Brunello, 2021; Boeri et al., 2016; Zhiyuan and Minghong, 2016), though

[5] Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, the United Kingdom, and the United States.

some have (Card and Lemieux, 2001; Mohnen, 2017). Card and Lemieux (2001) used the Constant Elasticity of Substitution (CES) production function of high-school and college labor by age group to determine whether a substitutionary relationship existed between age groups for a number of different jobs. Mohnen (2017) extended the concept of youth employment outcomes to include a qualitative dimension by dividing youth employment into several categories: (a) full-time and part-time employment and (b) employment in high-skill, middle-skill, and low-skill occupations. Mohnen showed that delayed retirement deteriorated youth employment in terms of quantity and quality. Using firm-level data, Bianchi et al. (2021) showed that substantial retirement delays among soon-to-retire workers due to a 2011 Italian pension reform hindered the careers of younger colleagues and postponed promotion of their colleagues. One of the adverse effects of delayed retirement was a decline in monthly contractual wage growth of colleagues who are not close to retirement yet.

2.2.2 Fertility

According to neoclassical fertility theory, a child is a normal good; thus, fertility positively relates to income level. However, in many industrialized countries, empirical evidence shows that income and fertility negatively relate to each other. To address this inconsistency, scholars have developed various models over the last several decades. Such efforts fit into two primary approaches.

One approach was to introduce the concept of the "quality" of children in the economic model, resulting in the quality-quantity tradeoff model (Becker, 1960; Becker and Lewis, 1973). According to this model, parents who want to maximize their utility care about the number of children (i.e., quantity) as well as the quality of children. Thus, as income increases, parents are likely to increase investment in their existing children to raise the quality of their children instead of having more children. That is, if income elasticity for the quality of children is sufficiently larger than the number of children, income might have a negative effect on fertility.

Another approach was to include the opportunity cost of women's time in a fertility decision-making model (Becker, 1965; Willis, 1973). Childrearing requires a time commitment from the parents, particularly the mother. Thus, the supply of women's labor negatively relates to fertility. In other words, when wages for women rise, they have a greater incentive to work, leading to a decrease in fertility. In line with this approach, an increase in educational opportunities for women, resulting in higher labor participation, is a primary cause of a decline in fertility (Monstad et al., 2008; Neels and De Wachter, 2010; Ní Bhrolcháin and Beaujouan, 2012).

In addition to these two approaches, previous findings show that fertility rate in many developed countries depends on factors that influence the motivation to have children (e.g., weak/strong altruism or non-altruism in the context of "old age security"). In such a model, fertility might decrease based on the social security tax rate and the generosity of social security benefits (Barro and Becker, 1989; Becker and Barro, 1988; Boldrin et al., 2015; Boldrin and Jones, 2002). Other scholars have explained the cause of decreasing childbirth using a recently developed bargaining model. While the Becker model assumes a unitary utility function, it assumes separate utility functions for wife and husband in a household. According to the newer model, fertility might depend on the bargaining power between wife and husband (Doepke and Kindermann, 2019; Komura, 2013; Youm and Lee, 2016).

Furthermore, researchers have long examined the relationship between fertility and economic conditions, particularly unemployment. Only a few have found that fertility is countercyclical (Butz and Ward, 1979); most have found that fertility negatively relates to unemployment, a phenomenon known as procyclicality, in many countries (Adserà, 2004; Cazzola et al., 2016; Mocan, 1990), both at individual and aggregate levels (Bono et al., 2015; Kravdal, 2002), and in the short and long term (Currie and Schwandt, 2014).

In recent years, the scope of research has expanded to include the concept of job instability. The definition of job instability depends on the focus of the research; thus, it varies slightly from study to study. Karabchuk (2020) found that job instability, defined as temporary employment, informal employment, or unemployment, led European youth to have lower intention to have children. Schneider (2015) found that poor economic conditions caused by the Great Recession in 2008 lowered fertility in the United States. Some findings show gender differences in the effect of job instability on fertility. Examining gender differences in the relationship between fertility and both unemployment and non-standard employment, Raymo and Shibata (2017) found that unfavorable employment conditions for men negatively related to marriage, whereas similar conditions for women led to higher levels of marriage and fertility. These results are consistent with Autor et al. (2019), who found, based on U.S. data, that a reduction in "marriageable" men due to adverse shocks to their labor market caused by rising international manufacturing competition lowered marriage and fertility rates.

2.2.3 Effect of retirement on fertility

Although the impact of retirement on fertility has received less attention, some scholars have examined this relationship using the concept of time transfer between generations. Battistin et al. (2014) found that pension reform in Italy increased grandparental time support during early childbearing years, increasing the number of children in regions characterized by traditional familism. Eibich and Siedler (2020) also investigated the effects of grandparental time support on birth rate in Germany and found that retirement of parents increased the likelihood that their adult offspring would have children.

2.3 Data

I used the two primary data sets: the Annual Social and Economic Supplement (ASEC) of CPS and the restricted U.S. birth data from the U.S. Vital Statistics. Because the goal was to examine whether the aging workforce ultimately affected fertility among young adults through labor market outcomes, classifying the economic activity status of young people was crucial. For this reason, I used ASEC of CPS data from 1994 to 2018. Since 1994, this dataset has included detailed labor force characteristics (i.e., "usual" work status), not merely work status during the "reference week."[6] As a result, I was able to classify economic activity based on the number of hours people

[6] This phrase refers to the period when the survey was conducted.

"usually" work each week.

The U.S. birth data include individual birth records for all live births. I used the restricted version because I needed information about the state in which a child was born. This data contains the mother's age, regional information, date of the child's birth, length of gestation, etc. In addition, I used O*NET Data, Population Estimates from the U.S. Census Bureau, and Data from the Bureau of Economic Analysis to construct various variables.

2.4 Empirical Analysis

2.4.1 Time series analysis

To analyze the effects of retirement delays among the elderly on the employment status of young adults and, ultimately, on childbirth, I regressed the following two equations:

$$Y_t = \alpha_0 + \alpha_1 * ELDERLYEMP_t + X_{1,t}\alpha_2 + \varepsilon_t \tag{2.1}$$

$$CONCEPTIONRATE_t = \beta_0 + \beta_1 * Y_t + X_{2,t}\beta_2 + T + T^2 + T^3 + \mu_t \tag{2.2}$$

where t represents the year (1994–2018). The first equation is for analyzing the impact on labor market outcomes of young adults. The second one is for analyzing the effects of a change in employment status on fertility. I regressed these two equations for each of the four age groups (i.e., 20–24, 25–29, 30–34, and 35–39).

Y represents the rates of five variables: (a) full-time[7] employment, (b) part-time employment for economic reasons, (c) part-time employment for noneconomic reasons, (d) unemployment, and (e) not in the labor force. An individual's employment status is in one of these five categories, so all five variables add up to 100%. The U.S. Bureau of Labor Statistics defines "persons employed part-time for economic reasons" as those who want and are available for full-time work but have

[7] In the United States, BLS classifies workers into two types: full-time (usually working 35 or more hours per week) and part-time (usually working fewer than 35 hours per week).

had to settle for a part-time schedule. In other words, part-time workers for economic reasons work part-time against their wishes; thus, the number of part-time workers reflects a degree of instability in the labor market. For this reason, I distinguished this status from voluntary part-time employment (i.e., part-time working for noneconomic reasons). X_1 contains gross domestic product (GDP) per capita, growth rate of GDP per capita, employment share of the manufacturing industry, employment share of routine occupations[8] and an index value for offshorability.[9] X_1 also includes population share of the higher educated, Black, Other, and Hispanic.

The first equation is similar to the model Gruber and Milligan (Gruber and Milligan, 2010) used. However, my analyses differ in several ways. First, I used detailed labor force statuses as dependent variables to consider the impact on both the quantity and the quality of youth employment. In contrast, Gruber and Milligan (Gruber and Milligan, 2010) used the unemployment rate and the employment rate. Second, I defined $ELDERLYEMP$ as the employment rate for people aged 66–70 to capture the impact of retirement delays among workers whose age exceeded FRA. Gruber and Milligan (Gruber and Milligan, 2010) used the employment rate among people aged 55–64 to determine the impact of early retirement. Third, I regressed this equation for four age groups (i.e., 20–24, 25–29, 30–34, and 35–39) because these groups closely relate in both the labor market and fertility, while Gruber and Milligan (Gruber and Milligan, 2010) divided workers into two groups: 20–24 (young adults) and 25–54 (prime). Finally, to control for changes in the industry and in occupations in the U.S. labor market, I added employment share of the manufacturing industry, employment share of routine occupations, and an index value for offshorability (Acemoglu and Autor, 2011; Autor et al., 2019). I also included population share of the higher educated, Black, Other, and Hispanic as demographic control variables. In contrast, Gruber and Milligan (Gruber and Milligan, 2010) included only gross domestic product (GDP) per capita and growth rate of GDP per capita as control variables.

$CONCEPTIONRATE$ is the number of conceptions by age group divided by the estimated

[8]Routine occupations include office and administrative support occupations, sales and related occupations, installation, maintenance, and repair occupations, and production occupations, following the classification of Acemoglu and Autor (Acemoglu and Autor, 2011).

[9]See Appendix 2.A1.

number of women in each respective age group multiplied by 1,000. I used three types of conception rates: (a) conception rate among all women, (b) conception rate among married women, and (c) conception rate among unmarried women.[10] This variable is similar to general fertility rate, which uses the number of live births. I used rate of conception due to the time lag between actual childbirth and the decision to have a baby. Economic conditions measured by the aggregate share of each labor force status at the time of conception are likely more relevant to the willingness to have a child.[11]

I regressed the second equation for each youth labor force characteristic to estimate the separate effects of employment status on fertility. To control for changes in fertility due to economic fluctuation, I included real GDP growth in the equation. I also controlled for race (i.e., Black, Hispanic, and Other) and high education level (i.e., college degree or higher). Additionally, I included women's employment rate and the ratio of the number of people married to the population. Finally, to account for secular trends in fertility, I added time trends denoted as T, T^2, and T^3.

Table 2.1 displays the impact of elderly employment on youth employment status for men and women together. The second column shows the results with only real GDP per capita and growth rate of GDP per capita as control variables (Gruber and Milligan, 2010). These results are partly consistent with Gruber and Milligan (2010) in that older workers crowded out young adults (i.e., aged 20–24) even though the magnitude of the impact was substantially different. Gruber and Milligan (2010) found that a one percentage point increase in older workers aged 55–64 decreased youth employment by 0.47 percentage points. I found that a one percentage point increase in older workers aged 66–70 decreased youth employment (aged 20–24) by 2.2 percentage points. Full-time employment in that age group decreased by 3.0 percentage points. This sizeable difference appears to be due to differences in the definition of older workers and the period of analysis.

[10] When calculating conception rate among all women, I obtained the number of women for each of the four age groups used as a denominator from Population Estimates from the U.S. Census Bureau. However, for conception rates among married and unmarried women, respectively, the number of women came from the ASEC of CPS. I divided the figures in 2014 by 2 because the aggregated number of married (unmarried) women using personal weights was almost twice as high as other years. I also excluded California when calculating both the numerator (i.e., number of conceptions) and the denominator (i.e., number of women) because information about marital status in California was not available in 2017 and 2018.

[11] Currie and Schwandt (2014) used conception rate instead of fertility rate for the same reason.

Table 2.1: Impact of elderly employment (ages 66–70) on youth employment

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-2.202***	-0.406*	-0.352*	-0.352*
	(0.381)	(0.227)	(0.171)	(0.177)
Full-time employment	-3.021***	-0.775**	-0.558**	-0.554*
	(0.491)	(0.365)	(0.247)	(0.285)
Part-time employment for economic reasons	0.974***	0.354***	0.295*	0.268*
	(0.135)	(0.118)	(0.145)	(0.147)
Part-time employment for noneconomic reasons	-0.156**	0.015	-0.089	-0.066
	(0.066)	(0.129)	(0.122)	(0.132)
Unemployment	1.019***	0.086	0.225	0.269
	(0.260)	(0.289)	(0.270)	(0.220)
Not in the labor force	1.183***	0.320*	0.127	0.083
	(0.215)	(0.182)	(0.193)	(0.139)
Ages 25–29				
Employment	-1.643***	-0.116	-0.199	-0.314
	(0.309)	(0.217)	(0.208)	(0.195)
Full-time employment	-2.348***	-0.523***	-0.437**	-0.515**
	(0.342)	(0.150)	(0.180)	(0.238)
Part-time employment for economic reasons	0.733***	0.301***	0.240***	0.192
	(0.096)	(0.092)	(0.074)	(0.112)
Part-time employment for noneconomic reasons	-0.029	0.106	-0.002	0.010
	(0.073)	(0.099)	(0.085)	(0.080)
Unemployment	0.858***	-0.035	0.062	0.022
	(0.223)	(0.210)	(0.198)	(0.209)
Not in the labor force	0.785***	0.151	0.137	0.292
	(0.166)	(0.217)	(0.162)	(0.200)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and outside the labor force) add up to 100%. Each coefficient comes from a separate equation for each labor force status. Economic conditions include GDP per capita and growth rate of GDP per capita. Occupational compositions contain employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years $\geq$ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.1: (continued) Impact of elderly employment (ages 66–70) on youth employment

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	-1.320***	0.012	-0.047	0.022
	(0.285)	(0.204)	(0.195)	(0.189)
Full-time employment	-1.662***	-0.088	-0.109	-0.035
	(0.320)	(0.209)	(0.192)	(0.177)
Part-time employment for economic reasons	0.522***	0.161*	0.120	0.038
	(0.086)	(0.092)	(0.091)	(0.070)
Part-time employment for noneconomic reasons	-0.179***	-0.062	-0.058	0.019
	(0.045)	(0.064)	(0.071)	(0.084)
Unemployment	0.857***	0.009	0.168	-0.011
	(0.211)	(0.189)	(0.155)	(0.160)
Not in the labor force	0.462***	-0.021	-0.121	-0.011
	(0.115)	(0.133)	(0.147)	(0.110)
Ages 35–39				
Employment	-1.119***	-0.208*	-0.176	-0.087
	(0.185)	(0.110)	(0.140)	(0.221)
Full-time employment	-1.393***	-0.306**	-0.241*	-0.021
	(0.221)	(0.115)	(0.137)	(0.205)
Part-time employment for economic reasons	0.528***	0.143*	0.113	-0.060
	(0.092)	(0.070)	(0.069)	(0.067)
Part-time employment for noneconomic reasons	-0.253***	-0.045	-0.048	-0.006
	(0.060)	(0.064)	(0.068)	(0.109)
Unemployment	0.851***	0.141	0.195	0.128
	(0.187)	(0.183)	(0.177)	(0.215)
Not in the labor force	0.268***	0.068	-0.019	-0.041
	(0.091)	(0.133)	(0.134)	(0.132)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and outside the labor force) add up to 100%. Each coefficient comes from a separate equation for each labor force status. Economic conditions include GDP per capita and growth rate of GDP per capita. Occupational compositions contain employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years $\geq$ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

I sequentially added control variables to the subsequent models. Columns 3–5 in Table 2.1 show the results controlling for the different sets of covariates. Overall, I found that an increase in elderly employment decreased full-time employment and increased part-time employment for economic reasons for age groups 20–24 and 25–29. In contrast, this pattern was unclear in age groups 30–34 and 35–39. Specifically, the results in column 5 show that a one percentage point increase in elderly employment decreased the full-time employment of young people aged 20–24 by 0.5 percentage points and increased part-time employment for economic reasons in the same group by 0.3 percentage points. I also found that postponement of retirement decreased the full-time employment of young adults aged 25–29 by 0.5 percentage points. On the contrary, the increase in older workers did not affect the employment status of age groups 30–34 and 35–39. This finding suggests that delayed retirement primarily influenced new entrants to the labor market. Similarly, Mohnen (2017) found that the retirement slowdown increased part-time employment among young adults aged 22–30 in 722 commuting zones.

Table 2.2 shows the effects of each employment status on fertility by age group. The impacts of each employment status vary slightly by age group. Generally, both part-time employment for economic reasons and unemployment were negatively associated with fertility for all age groups. Note that the negative effect of part-time employment for economic reasons on fertility is greater than that of unemployment. One possible explanation is that the voluntary unemployed, is one of the components of the unemployed, can easily shift their labor force characteristics to full-time employment while part-time workers, who do not find a full-time job but want to work as full-time workers, can be trapped in their unstable and low paying jobs (Cai et al., 2014; Nightingale, 2020).

In each age group except 35–39, full-time employment positively related to fertility. These results support the idea of procyclical fertility, which is the empirical regularity of the relationship between economic conditions and fertility (Adserà, 2004; Cazzola et al., 2016; Bono et al., 2015; Currie and Schwandt, 2014; Kravdal, 2002; Mocan, 1990).

Table 2.2: Impact of youth employment status on fertility (conception rate)

	All	Married	Unmarried
Ages 20–24			
Employment	1.212***	2.655	0.599
	(0.302)	(2.378)	(0.423)
Full-time employment	0.722***	2.622**	0.226
	(0.166)	(1.111)	(0.201)
Part-time employment for economic reasons	-1.559***	-6.486**	-0.479
	(0.301)	(2.184)	(0.389)
Part-time employment for noneconomic reasons	-0.173	-10.601*	1.724
	(1.319)	(5.366)	(1.031)
Unemployment	-0.987***	-2.589	-0.424
	(0.225)	(1.777)	(0.295)
Not in the labor force	1.262	5.265	0.250
	(0.786)	(4.545)	(0.526)
Ages 25–29			
Employment	1.546***	2.608	1.152***
	(0.441)	(1.589)	(0.339)
Full-time employment	1.099***	1.592	0.866**
	(0.325)	(1.156)	(0.293)
Part-time employment for economic reasons	-2.073***	-3.451	-1.676**
	(0.672)	(2.558)	(0.746)
Part-time employment for noneconomic reasons	1.722	5.488*	1.097
	(1.557)	(2.932)	(1.452)
Unemployment	-1.233***	-1.827	-0.987***
	(0.379)	(1.235)	(0.297)
Not in the labor force	1.923	1.066	2.014
	(1.549)	(4.475)	(1.152)

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and outside the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. All regressions include real GDP growth rate, women's employment share, population share of married, higher education level (education year $\geq$ 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Despite differences in the magnitude and significance of the effects of each employment status on fertility among both married and unmarried women, columns 3 and 4 of Table 2.2 show that fertility essentially tended to be procyclical. I found that childbirth among married couples in the

Table 2.2: (continued) Impact of youth employment status on fertility (conception rate)

	All	Married	Unmarried
Ages 30–34			
Employment	1.580*	0.948	0.851*
	(0.786)	(0.978)	(0.445)
Full-time employment	1.061**	0.624	0.550**
	(0.402)	(0.624)	(0.224)
Part-time employment for economic reasons	-2.303**	-0.978	-1.127**
	(0.768)	(1.299)	(0.489)
Part-time employment for noneconomic reasons	0.239	-1.128	0.043
	(2.354)	(2.381)	(1.165)
Unemployment	-1.330**	-0.589	-0.589
	(0.565)	(0.688)	(0.439)
Not in the labor force	1.637*	0.355	0.498
	(0.789)	(1.044)	(0.661)
Ages 35–39			
Employment	0.723	1.372	0.104
	(0.628)	(0.898)	(0.286)
Full-time employment	0.592	1.109*	0.119
	(0.408)	(0.584)	(0.183)
Part-time employment for economic reasons	-2.159***	-3.080***	-1.003***
	(0.374)	(0.638)	(0.310)
Part-time employment for noneconomic reasons	1.778*	1.642	1.255*
	(0.863)	(1.413)	(0.633)
Unemployment	-0.871***	-1.278***	-0.504**
	(0.233)	(0.371)	(0.171)
Not in the labor force	1.115**	1.383*	0.900***
	(0.389)	(0.649)	(0.222)

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and outside the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. All regressions include real GDP growth rate, women's employment share, population share of married, higher education level (education year $\geq$ 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

20–24 age group responded most sensitively to changes in employment status and that childbirth among unmarried couples in that age group were unaffected by changes in employment status. For age groups 25–29 and 30–34, fertility among unmarried couples was primarily influenced by changes in employment status, while fertility among married couples in the same age groups was hardly affected by labor market outcomes except for part-time employment for noneconomic reasons in the 25–29 age group. On the contrary, both types of fertility among women aged 35–39 were affected by labor market outcomes.

Table 2.3 summarizes the valid cases through which the increase in older workers affected fertility through the labor market outcomes of young adults: (a) reducing full-time workers among young adults aged 20–24 and 25–29 and (b) raising part-time workers among young adults aged 20–24.[12] I considered a valid path one in which the coefficients obtained from the first set of equations (i.e., effects of elderly employment on youth employment) and the coefficients obtained from the second set of equations (i.e., effects of youth employment on fertility) were both significant.

Table 2.3: Summary: Impacts of elderly employment (66–70) on fertility through labor market outcomes (pooled men and women)

	Elderly Employment → Youth Employment	Youth Employment → Conception Rate
Panel A. All		
Ages 20–24		
Full-time employment	-0.554*	0.722***
	(0.285)	(0.166)
Part-time employment for economic reasons	0.268*	-1.559***
	(0.147)	(0.301)
Ages 25–29		
Full-time employment	-0.515**	1.099***
	(0.238)	(0.325)
Panel B. Married		
Ages 20–24		
Full-time employment	-0.554*	2.622**
	(0.285)	(1.111)
Part-time employment for economic reasons	0.268*	-6.486**
	(0.147)	(2.184)
Panel C. Unmarried		
Ages 25–29		
Full-time employment	-0.515**	0.866**
	(0.238)	(0.293)

Note. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

[12] See Appendix, Table 2.C2 for the full set of results.

I defined the impact on fertility by a change in employment status due to an increase in older workers as the product of (a) the effect of delayed retirement on the employment status of young adults (i.e., α_1 in equation (2.1)) and (b) the effect of employment status on fertility (i.e., β_1 in equation (2.2)). Numerically, a one percentage point increase in older workers aged 66–70 decreased fertility by 0.8 conceptions (-0.554 * 0.722 + 0.268 * -1.559) per 1,000 women for young adults aged 20–24 and by 0.6 conceptions (-0.515 * 1.099) for young adults aged 25–29. Based on the results of the sub-group analysis according to marital status, the decrease in childbirth among young adults aged 20–24 occurred in married couples, while the decrease in childbirth among young adults aged 25–29 occurred in unmarried couples. Specifically, a one percentage point increase in older workers decreased fertility by 3.2 conceptions (0.554*-2.622 + 0.268*-6.486) per 1,000 married women aged 20–24 and by 0.4 conceptions (0.515*-0.866) for unmarried women aged 25–29.

Changes in labor market conditions can disproportionately affect the employment statuses of men and women. To see how differently an increase in the aging workforce changed labor market outcomes for men and women, I analyzed equations (2.1) and (2.2) by gender. Similar to the pooled data, the increase in older workers affected both men and women in age groups 20–24 and 25–29.[13]

Interestingly, however, the influence of elderly employment on youth employment status differed between men and women, even when the result was different from the regressions for men and women pooled together. For example, for age group 20–24, I found no evidence of a decrease in full-time employment for men or women, while the results from the pooled sample did show a decrease in full-time employment. Nonetheless, I found some evidence that the quality of employment in this group deteriorated due to delayed retirement. A one percentage point increase in older workers raised job instability among young people aged 20–24 by increasing the part-time employment for economic reasons of men by 0.3 percentage points and the unemployment of women by 0.4 percentage points. These changes led to a decrease in fertility by 0.4 (0.290 *

[13] See Appendix, Tables 2.C3–2.C6 for the full set of results.

-1.478) conceptions for men and by 0.9 (0.381 * -2.291) conceptions for women.

Table 2.4: Summary: Impact of elderly employment (66–70) on fertility through labor market outcomes (men and women separately)

	Elderly Employment → Youth Employment	Youth Employment → Conception Rate
Panel A. Men		
A1. All		
Ages 20–24		
Part-time employment for economic reasons	0.290*	-1.478***
	(0.164)	(0.259)
Ages 25–29		
Not in the labor force	0.253*	-1.436***
	(0.141)	(0.452)
A2. Married		
Ages 20–24		
Part-time employment for economic reasons	0.290*	-5.967**
	(0.164)	(2.261)
Panel B. Women		
B1. All		
Ages 20–24		
Unemployment rate	0.381**	-2.291***
	(0.158)	(0.600)
Ages 25–29		
Full-time employment	-0.481**	-0.507**
	(0.213)	(0.231)
B2. Married		
Ages 20–24		
Part-time employment for economic reasons	0.247*	-8.606**
	(0.138)	(3.474)

Note. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

For age group 25–29, I found that delayed retirement induced younger male workers to leave the labor market, decreasing fertility by 0.4 (0.253 * -1.436) conceptions. However, the results for women tell a different story. A one percentage point increase in older workers decreased full-time employment of women by 0.5 percentage points. Not surprisingly, full-time employment of women in this age group negatively related to fertility, controlling for men's employment. In this case, older workers caused fertility among young adults aged 25–29 to increase by 0.2 (-0.481 * -0.507) conceptions by lowering women's full-time employment.

Furthermore, I found that a slowdown in retirement, lowering the quality of employment among young adults aged 20–24, also significantly reduced fertility among married couples in that age group. This phenomenon was common in both men and women. By increasing part-time employment for economic reasons, a one percentage point increase in older workers decreased fertility by 1.7 (0.290*-5.967) conceptions through a change in men's employment status and by 2.1 (0.247*-8.606) conceptions through a change in women's employment.

2.4.2 Panel analysis

To examine whether postponed retirement affected childbirth among young adults at the state level, I estimated the following two equations:

$$Y_{s,t} = \alpha_1 * ELDERLYEMP_{s,t} + X_{1,s,t}\alpha_2 + \zeta_s + \tau_t + \varepsilon_{s,t} \tag{2.3}$$

$$CONCEPTIONRATE_{s,t} = \beta_1 * Y_{s,t} + X_{2,s,t}\beta_2 + \zeta_s + \tau_t + \mu_{s,t} \tag{2.4}$$

where s represents state and t represents year. For panel analysis, I divided youth employment status into only three categories: (a) employment, (b) unemployment, and (c) not in the labor force. Due to substantial missing cases for part-time employment for economic reasons aggregated at the state level, I did not break down employment status as far as I did for time series analysis. I also included state and year fixed effects. Control variables were the same as equations (2.1) and (2.2), but I aggregated the variables at the state level.

Table 2.5 presents the impact of elderly employment on the labor market outcomes of young adults. A one percentage point increase in elderly employment decreased the employment of age group 20–24 by 0.05 percentage points and increased the ratio of young adults who were not in the labor force by 0.06 percentage points. Considering that elderly employment decreased employ-

Table 2.5: Impact of elderly employment (ages 66–70) on youth employment at state level

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.025	-0.031	-0.040*	-0.049**
	(0.023)	(0.022)	(0.021)	(0.020)
Unemployment	-0.018	-0.016	-0.017	-0.012
	(0.012)	(0.012)	(0.012)	(0.012)
Not in the labor force	0.043*	0.047**	0.056**	0.061***
	(0.023)	(0.022)	(0.021)	(0.021)
Ages 25–29				
Employment	0.017	0.014	0.013	0.005
	(0.026)	(0.025)	(0.026)	(0.024)
Unemployment	-0.020	-0.019	-0.020	-0.017
	(0.014)	(0.014)	(0.014)	(0.014)
Not in the labor force	0.001	0.003	0.005	0.011
	(0.020)	(0.020)	(0.020)	(0.020)
Ages 30–34				
Employment	0.025	0.021	0.019	0.010
	(0.021)	(0.022)	(0.022)	(0.022)
Unemployment	-0.024*	-0.022*	-0.022*	-0.022*
	(0.012)	(0.013)	(0.013)	(0.013)
Not in the labor force	-0.002	0.001	0.003	0.012
	(0.017)	(0.016)	(0.017)	(0.017)
Ages 35–39				
Employment	0.043**	0.041**	0.035*	0.022
	(0.018)	(0.018)	(0.019)	(0.019)
Unemployment	-0.018	-0.018	-0.017	-0.014
	(0.011)	(0.011)	(0.011)	(0.010)
Not in the labor force	-0.024	-0.022	-0.017	-0.006
	(0.017)	(0.017)	(0.017)	(0.018)
State & Year dummies	Yes	Yes	Yes	Yes
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. N = 1,275 (51 states * 25 years). Each coefficient comes from a separate equation for each labor force status. All control variables are the same as Table 2.1 but aggregated at the state level. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

ment in this age group by 0.35 percentage points in the time series analysis, the size of the estimated effect from state-level analysis is minimal. Except for unemployment in age group 30–34, I found no evidence that delayed retirement changed employment status for the other three age groups.

Table 2.6 presents the impact of changes in labor force status on fertility. The results confirm the procyclicality of fertility for all groups in terms of direction. However, statistically meaningful results emerged only for age group 20–24, showing that their employment positively related to fertility and that unemployment negatively related to fertility. A one percentage point increase in the employment rate of young adults aged 20–24 raised conceptions by 1.8 per 10,000 women, and a one percentage point increase in their unemployment rate decreased conceptions by 1.6 per 10,000 women. A one percentage point increase in people who are not in the labor force decreased conceptions by 0.8 per 10,000 women.

Interestingly, as a result of sub-group analysis according to marital status, changes in employment status in age group 20–24 did not significantly influence fertility in married and unmarried couples. This outcome differs from the results of the time-series analysis. On the other hand, the results for married couples in age groups 25–29, 30–34, and 35–39 confirmed that fertility is procyclical. In other words, employment positively related to fertility. Moreover, unemployment and being outside the labor force negatively related to fertility. The regularity of this empirical analysis of childbirth also surfaced in the results for unmarried couples in the same age groups, even though the results were less clear than those for married couples in terms of statistical significance. One finding, contrary to this overall trend, is that an increase in unemployment among people aged 30–34 increased births among unmarried women by 0.3 conceptions per 1,000. This result is partially consistent with the result from Autor et al. (2019), who found that an adverse shock on men in the labor market negatively related to total births among all women but positively related to births among unmarried mothers.

Table 2.6: Impact of youth employment on fertility at state level

	All	Married	Unmarried
Ages 20–24			
Employment	0.180***	0.445	0.141
	(0.065)	(1.340)	(0.113)
Unemployment	-0.162*	1.427	0.014
	(0.093)	(2.056)	(0.147)
Not in the labor force	-0.077*	-1.299	-0.137
	(0.045)	(1.436)	(0.107)
Ages 25–29			
Employment	0.046	0.794**	0.166
	(0.095)	(0.307)	(0.152)
Unemployment	-0.113	-1.470***	-0.279
	(0.086)	(0.484)	(0.173)
Not in the labor force	0.029	0.191	0.019
	(0.084)	(0.361)	(0.161)
Ages 30–34			
Employment	0.070	0.538***	0.013
	(0.069)	(0.190)	(0.114)
Unemployment	-0.068	0.256	0.270*
	(0.074)	(0.227)	(0.135)
Not in the labor force	-0.026	-0.892***	-0.279**
	(0.069)	(0.189)	(0.129)
Ages 35–39			
Employment	0.030	0.350***	0.142**
	(0.028)	(0.080)	(0.068)
Unemployment	-0.018	-0.003	-0.066
	(0.037)	(0.105)	(0.088)
Not in the labor force	-0.017	-0.364***	-0.108
	(0.019)	(0.090)	(0.066)

Note. N = 1,275. (51 states * 25 years). Each coefficient comes from a separate equation for each labor force status. All control variables are the same as Table 2.2 but aggregated at the state level. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.7 summarizes the valid pathways through which delayed retirement decreased fertility among young adults through labor market outcomes. By lowering the employment rate of young adults aged 20–24 and raising the proportion of those who were outside the labor force, the increase in older workers aged 66–70 decreased fertility of women aged 20–24 by 0.1 conceptions per 10,000 women. This effect is tiny compared to the total impact on fertility from the time series analysis.

In the analysis dividing conception into two categories (i.e., married and unmarried women), I found that births among married couples in all four age groups were not affected by an increase in older workers staying in the labor market beyond their full retirement age. However, increased numbers of older workers lowered the unemployment rate among those aged 30–34, in turn reducing births among unmarried mothers in the same age group by 0.06 conceptions per 10,000. Indeed, the increase in the unemployment rate in this age group positively related to births among unmarried couples.

Table 2.7: Summary: Impact of elderly employment (ages 66–70) on fertility through labor market outcomes at state level

	Elderly Employment → Youth Employment	Youth Employment → Conception Rate
Panel A. All		
Ages 20–24		
Employment	-0.049**	0.180***
	(0.020)	(0.065)
Not in the labor force	0.061***	-0.077*
	(0.021)	(0.045)
Panel B. Unmarried		
Ages 30–34		
Unemployment	-0.022*	0.270*
	(0.013)	(0.135)

Note. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

2.5 Robustness Check

2.5.1 Time series analysis

To investigate how the effects of older workers on fertility differed from the previous results, I adopted a reduced form in this section, constructing the following equation:

$$CONCEPTIONRATE_t = \gamma_0 + \delta * ELDERLYEMP_t + X_{1,t}\gamma_1 + X_{2,t}\gamma_2 + T + T^2 + T^3 + \varepsilon_t \quad (2.5)$$

where the vectors of covariates X_1–X_2 include the same control variables used in equations (2.1) and (2.2) such as economic conditions, manufacturing employment share, occupational composition, and population composition. While the previous section shows how an increase in older workers related to fertility by labor force status, the reduced form allowed me to obtain the overall effect of delayed retirement on childbirth directly.

According to the results reported in Table 2.8, a one percentage point increase in older workers aged 66–70 caused fertility in age group 20–24 to fall by 0.7 conceptions per 1,000 women and fertility in age group 25–29 to fall by 0.8 conceptions. For age group 20–24, the reduction in fertility estimated using the reduced form is close to the amount from the first method, whereas the reduction for age group 25–29 was not. This difference might be attributable to the effect of part-time workers for economic reasons not taken into account when calculating the total effect on fertility in age group 25–29 in the first method. As shown in Table 2.1, the coefficients of part-time employment for economic reasons among young adults aged 25–29 were significant in three models. Even though the coefficient in the fourth model reported in column 5 in Table 2.1 was not significant, the p-value was 0.108. If I had considered this effect a valid case, the total effect on fertility in age group 25–29 in the first method would have been 0.9 conceptions (-0.515 * 1.099 + 0.192 * -2.073), closer to the effect derived using the reduced form. As in the first method, I found that fertility rates in age groups 30–34 and 35–39 did not relate to delayed retirement.

For analyses of conception rate by married and unmarried women, a one percentage point increase in older workers decreased fertility in married couples aged 25–29 by 3 conceptions per 1,000 women. Although, in terms of the total effect of delayed retirement on young adults regardless of age group, this result is similar to the result in the previous section (i.e., a one percentage point increase in older workers caused fertility among married couples aged 20–24 to fall by 3.2

conceptions through a decrease in full-time employment and an increase in part-time employment), the two methods did not necessarily produce the same result because the age group affected by the increased number of older workers differed for each method. For unmarried couples, a one percentage point increase in older workers reduced fertility by 0.9 conceptions for those aged 20–24, a result differs from that in Section 2.4.1 in terms of magnitude.

Table 2.8: Impact of elderly employment (ages 66–70) on fertility

	Conception Rate			
Age group	20–24	25–29	30–34	35–39
Panel A. All				
Elderly employment	-0.676**	-0.839*	-0.302	-0.257
	(0.253)	(0.403)	(0.384)	(0.287)
Panel B. Married				
Elderly employment	-0.681	-3.258**	-0.574	-0.161
	(2.247)	(1.401)	(0.627)	(0.292)
Panel C. Unmarried				
Elderly employment	-0.899**	-0.652	0.153	-0.109
	(0.318)	(0.403)	(0.144)	(0.328)

Note. T = 25. Each coefficient comes from a separate equation for each age group. All control variables are the same as Tables 2.1 and 2.2. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Through the results from the two methodologies, I generally confirmed the two findings: (a) an increase in older workers aged 66–70 adversely affected fertility among young adults regardless of marital status and (b) this negative impact on fertility was concentrated on people aged 20–24 and 25–29 who had just entered the labor market. The second finding is in line with Mohnen (2017): "Retirement trends have contributed to stagnant youth labor market prospects in recent years" (p.1). This result suggests that the outcomes of the labor market significantly connect to milestone events such as marriage and childbirth.

2.5.2 Panel analysis

I used a reduced form for state-level analysis to determine how the results might depend on methodology. I regressed the following equation:

$$CONCEPTIONRATE_{s,t} = \delta * ELDERLYEMP_{s,t} + X_{1,s,t}\gamma_1 + X_{2,s,t}\gamma_2 + \zeta_s + \tau_t + \varepsilon_{s,t} \quad (2.6)$$

where the vectors of covariates X_1–X_2 are the same as the control variables in equations (2.3) and (2.4). Table 2.9 reports the results from the reduced form. I found that delayed retirement did not relate to any of the fertility types among young people at the state level.

Table 2.9: Impact of elderly employment (ages 66–70) on fertility at state level

	Conception Rate			
Age group	20–24	25–29	30–34	35–39
Panel A. All				
Elderly employment	-0.004	-0.039	-0.029	0.003
	(0.031)	(0.037)	(0.020)	(0.009)
Panel B. Married				
Elderly employment	1.078	0.134	-0.036	0.029
	(1.471)	(0.178)	(0.068)	(0.031)
Panel C. Unmarried				
Elderly employment	-0.047	0.044	0.044	0.025
	(0.063)	(0.066)	(0.048)	(0.023)

Note. N = 1,275 (51 states * 25 years). Each coefficient comes from a separate equation for each age group. All control variables are the same as Tables 2.1 and 2.2 but aggregated at the state level. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

2.6 Discussion

Overall, the results suggest that an increase in older workers worsened the labor market outcomes of young adults, especially those aged 20–29, ultimately decreasing their fertility. These findings partly explain the steady decline in the fertility rates of age groups 20–24 and 25–29 since the mid-

2000s.[14] The findings suggest that an increase in older workers acted as an economic downturn for new entrants, limiting the number of high-quality jobs available. From this point of view, the results are not surprising, for young workers in the early stages of their careers are particularly vulnerable to unfavorable labor market conditions. Indeed, delayed retirement deteriorated the quality of employment of young adults by reducing the number of full-time workers and increasing the number of part-time workers for economic reasons among young adults. This deterioration, in turn, led to a sharp decline in fertility in age groups 20–24 and 25–29. Indeed, increasing numbers of older workers can compromise the willingness of younger people to have children.

Numerically, based on the time series results broken down by employment status, a one percentage point increase in elderly employment caused fertility to fall by 0.82 conceptions per 1,000 women aged 20–24 and by 0.56 conceptions per 1,000 women aged 25–29. Given that the elderly employment rate increased from 18% to 29% from 1994 to 2018, total births decreased by 7.4 (accounting for 20% of the total decrease) in age group 20–24. In particular, married couples in age group 20–24 played a significant role in the decline of 7.4 conceptions. For age group 25–29, total births decreased by 5.1 (accounting for 40% of the total decrease), driven primarily by the decline among unmarried couples.[15]

This result has implications for countries considering an extension of the retirement age as a way to sustain social security programs. Most of these countries have already begun experiencing the combined effects of low birth rate and an aging population. In fact, many countries have implemented or intend to implement the following two policies: (a) increasing the legal retirement age or (b) raising the age at which pension benefits become available. In Germany, the retirement age is supposed to increase gradually to 67 years by 2029. Japan has also approved bills to urge businesses to let employees work until age 70. In the United Kingdom, the State Pension age increased to 66 on October 6, 2020 and will increase to 67 by 2028 and 68 by 2037. The United States also increased FRA through its amendments to Social Security in 1983; the current FRA is 66 and will

[14]See Appendix, Figure 2.B2.

[15]During the period 1994–2018, the fertility rate of the age group 20–24 decreased from 108 births per 1,000 women to 71 births. For the age group 25–29, the fertility rate decreased from 109 births to 96 births.

be 67 by 2027 for everyone born in 1960 or later. The main finding of the current study implies that such policies giving incentives to older people staying in the labor market might accelerate the problems that arise from low birth rate, one of the key factors threatening the sustainability of social pension programs in the first place.

2.7 Conclusion

Since the mid-2000s, both total births and TFR have continued to decrease in the United States. This situation is somewhat unusual because TFR in the United States hovered around the population replacement rate of 2.1 for a long time, preventing any detrimental outcomes related to low birth rate. Because fertility closely relates to economic fluctuations, the observed decline in fertility in recent years might be attributable to the business cycle. However, TFR began to decline between the Early 2000s recession in 2001 and the Great Recession in 2008. The economic downturn cannot fully explain the point at which the two indicators of fertility began to decrease or the continuity of the decline since.

At the same time, a striking feature found in the U.S. labor market is the significant increase in the older workforce. In particular, the timing of the decline in fertility coincides with the timing of the increase in the number of workers in the labor market. FRA increased sequentially by two months from 2003 to 2008 and Baby Boomers reached the age of 65 in 2011. Motivated by to explain this coincidence, I examined whether an increase in older workers affected the employment status of young adults and, ultimately, their willingness to have children.

First, I found that the increase in older workers aged 66–70 decreased the full-time employment and increased the part-time employment for economic reasons of young adults aged 20–29, but it did not affect the employment status of those aged 30–39. This finding implies that new entrants in the labor market bear most of the burden of the adverse shock of the market. The pattern that the aging workforce only affects the labor market outcomes of those aged 20–29 was similar for pooled and unpooled men and women.

Second, I found that, in general, full-time employment positively related to fertility, while part-time employment for economic reasons and unemployment negatively related to fertility. These results are consistent with numerous previous findings that fertility is procyclical. However, when analyzing men and women separately, the story is quite different: full-time employment of women aged 25–29 negatively related to birthrate.

Based on these findings, I identified two pathways through which the increase in the aging workforce harmed fertility in young adults: (a) lowering the number of young adults aged 20–24 employed as full-time workers and (b) raising the number of young adults aged 20–24 and 25–29 employed as part-time workers for economic reasons. Married couples had the highest decline in fertility in age group 20–24, and unmarried couples had the highest decline in fertiliy in age group 25–29. The decline in fertility through these pathways accounts for 20% of the total decrease in fertility for young adults aged 20–24 and 40% for young adults aged 25–29. The findings suggest that the policy increasing FRA to 67 years in 2027 for Baby Boomers born in 1960 or later could have a negative effect on fertility, especially childbirth among married young adults aged 20–24, in the United States, given that social security benefits greatly influence retirement decisions among older people (Börsch-Supan and Coile, 2018; Coile and Gruber, 2007; Gustman and Steinmeier, 2009; Hurd, 1990; Ruhm, 1995).

Finally, unlike the time series analysis, I discovered that older workers had little effect on employment status and fertility among young adults at the state level. The results show that the increase in elderly employment was an unfavorable shock to young people aged 20–24, ultimately decreasing fertility in that age group. Nonetheless, the estimates themselves were negligible, possibly because the local labor market defined by the administrative district (i.e., state-level labor market) might not have captured the actual labor market. To rule out this issue and to examine local labor markets more closely, many scholars have used the commuting zones developed to understand local economies better (Autor et al., 2019; Autor and Dorn, 2013; Mohnen, 2017). However, I could not access the restricted CPS data that might allow me to identify commuting zones at the county level. Therefore, further study on this topic is required at commuting zone level.

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Appendix A. Variables

2.A1 Offshorability

Offshorability is an index measuring the extent to which occupations are possible to offshore. To construct this index, I used work context elements from the O*NET data. Work context data contains physical and social factors that affect the nature of work, all of which are quantifiable. Work context consists of three categories: (a) interpersonal relationships (14 items), (b) physical work conditions (30 items), and (c) structural job characteristics (13 items). I used the following items: "face-to-face discussion," "establishing and maintaining interpersonal relationships," "assisting and caring for others," "performing for or working directly with the public," "coaching and developing others," "inspecting equipment, structures, or material," "handling and moving objects," "operating vehicles, mechanized devices, or equipment," "repairing and maintaining mechanical equipment," and "repairing and maintaining electronic equipment."

To calculate offshorability, I followed an approach used by Firpo et al. (2011) and and Autor and Dorn (2013). Firpo et al. viewed the degree of "face-to-face contact" and the degree of working an "on-site job" as key elements in determining whether to offshore. "Face-to-face" is the average value of "face-to-face discussion," "establishing and maintaining interpersonal relationships," "assisting and caring for others," "performing for or working directly with the public," and "coaching and developing others." Furthermore, "on-site job" is the average value of "inspecting equipment, structures, or material," "handling and moving objects," "operating vehicles, mechanized devices, or equipment," and the mean of "repairing and maintaining mechanical equipment" and "repairing and maintaining electronic equipment." Offshorability derives from simply averaging the two aggregate variables; this average actually yields non-offshorability.

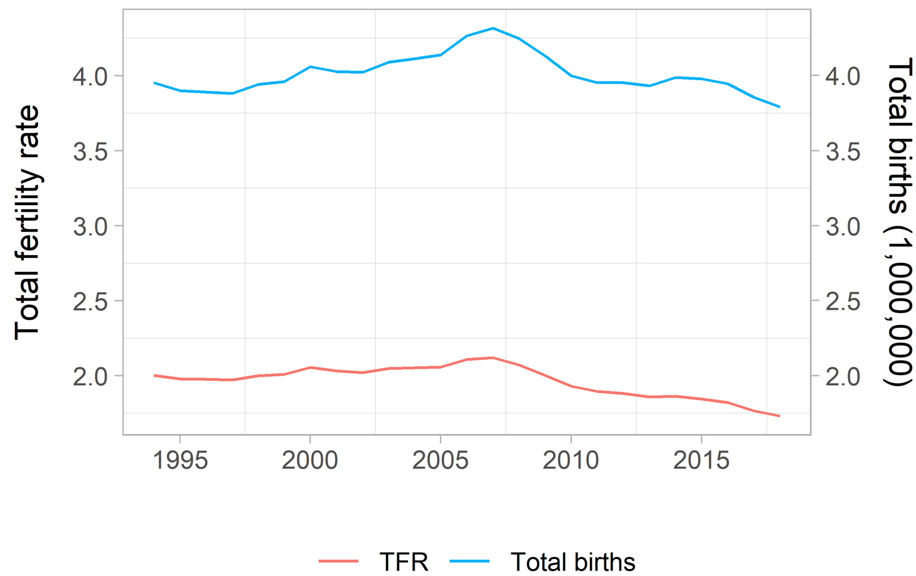
O*NET data use Standard Occupational Classification (SOC) code while ASEC data follow the Census Bureau's occupation classification scheme. To match the occupation codes of the two data sets, I used a matched list between the 2010 Census Code and the 2010 SOC Code provided by U.S. Census Bureau. I also used only major and minor group information in the SOC code by dropping three of the six digits, minimizing detail that would make matching occupations between the two data sets too difficult.

2.A2 GDP Data from the Bureau of Economic Analysis

In 1997, GDP calculation changed from Standard Industrial Classification (SIC) to North American Industry Classification System (NAICS). The several differences between SIC-based GDP and NAICS-based GDP arise from different data sources and the statistical discrepancy between GDP and gross domestic income (GDI). NAICS-based estimates are based on GDP, while SIC-based estimates are based on GDI. For these reasons, the 1997 estimates of NAICS-based GDP differ slightly from the 1997 estimates of SIC-based GDP, including the state totals. Nevertheless, I used SIC-based GDP for 1994–1996 for the state-level data because the difference was not significant. Moreover, I transformed GDP to GDP per capita and GDP growth rate.

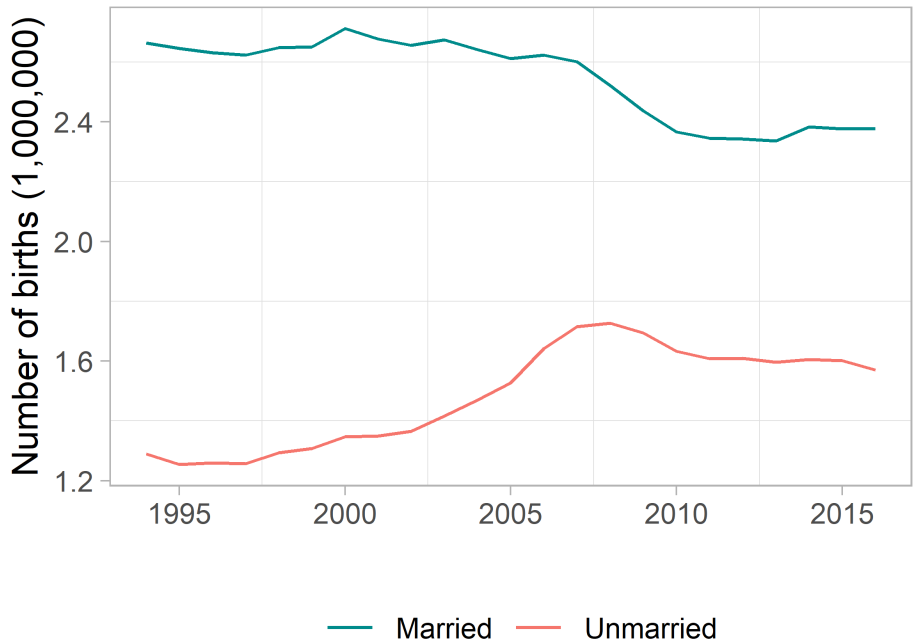
Appendix B. Figures

Figure 2.B1: Trends in TFR and total births in the United States



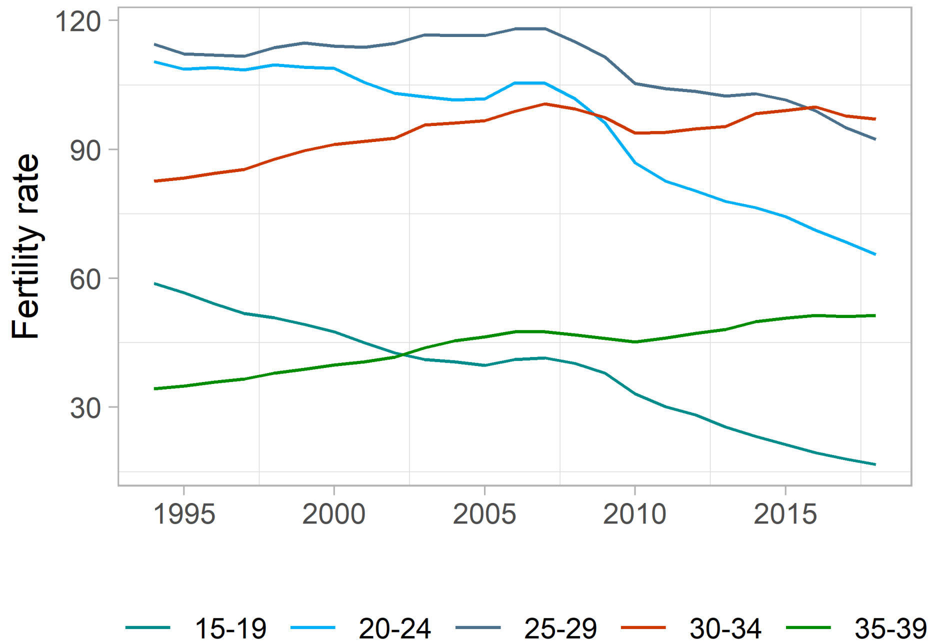
Data. TFR from OECD and restricted birth data from U.S. Vital Statistics.
Note. TFR is the average number of children that would be born to a woman over her lifetime if (a) she were to experience the exact current age-specific fertility rates through her lifetime and (b) she were to survive from birth to the end of her reproductive life. Total births are all births in the 51 states of the United States.

Figure 2.B2: Number of births by marital status in the United States



Data. Restricted birth data from U.S. Vital Statistics.
Note. I calculated number of births by marital status from 1994 to 2016 because marital status in California of almost all births was not available in 2017 and 2018.

Figure 2.B3: Trends in fertility rates by age group in the United States



Data. Restricted birth data from U.S. Vital Statistics and population estimates from U.S. Census Bureau.
Note. Fertility rates are calculated by dividing all live births to women of a certain age group by the total number of women in that age group. The sample is restricted to the 51 states of the United States.

Appendix C. Tables

Table 2.C1: Descriptive statistics of main variables

Conception years	1994–2018	1994–2007	2008–2018
Conception rate (All)			
20–24	97.5	108.0	84.2
25–29	110.6	113.8	106.5
30–34	89.0	85.0	94.2
35–39	38.8	35.2	43.2
Conception rate (Married)			
20–24	233.5	239.6	225.9
25–29	172.2	170.8	173.9
30–34	117.5	111.0	125.7
35–39	46.7	42.9	51.5
Conception rate (Unmarried)			
20–24	65.6	68.0	62.5
25–29	57.7	54.2	62.0
30–34	41.3	35.0	49.4
35–39	20.0	16.0	25.1
Full-time employment rate (%)			
20–24	43.9	47.8	38.9
25–29	65.7	68.0	62.8
30–34	68.2	69.5	66.5
35–39	68.9	69.9	67.6
Part-time employment rate for economic reasons (%)			
20–24	3.9	3.0	5.1
25–29	2.7	2.0	3.7
30–34	2.1	1.6	2.8
35–39	2.0	1.5	2.6
Part-time employment rate for noneconomic reasons (%)			
20–24	17.8	17.6	18.2
25–29	8.2	8.2	8.1
30–34	7.8	8.2	7.3
35–39	8.0	8.5	7.3

Data. Restricted birth data from U.S. Vital Statistics, population estimates from U.S. Census Bureau, and ASEC of CPS.
Note. Conception rate is defined as conceptions by age group divided by the estimated number of women in that age group multiplied by 1,000.

Table 2.C1: (continued) Descriptive statistics of main variables

Conception years	1994–2018	1994–2007	2008–2018
Unemployment rate (%)			
20–24	7.6	7.0	8.3
25–29	5.7	5.0	6.6
30–34	4.8	4.3	5.5
35–39	4.4	3.9	5.0
Not in the labor force (%)			
20–24	26.8	24.7	29.5
25–29	17.7	16.8	18.9
30–34	17.1	16.5	17.9
35–39	16.7	16.1	17.4
Employment rate aged 66–70 (%)	24.2	21.5	27.5

Data. Restricted birth data from U.S. Vital Statistics, population estimates from U.S. Census Bureau, and ASEC of CPS.
Note. Conception rate is defined as conceptions by age group divided by the estimated number of women in that age group multiplied by 1,000.

Table 2.C2: Summary: Impacts of elderly employment (ages 66–70) on fertility through labor market outcomes (pooled men and women)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.352*	1.212***	2.655	0.599
	(0.177)	(0.302)	(2.378)	(0.423)
Full-time employment	-0.554*	0.722***	2.622**	0.226
	(0.285)	(0.166)	(1.111)	(0.201)
Part-time employment for economic reasons	0.268*	-1.559***	-6.486**	-0.479
	(0.147)	(0.301)	(2.184)	(0.389)
Part-time employment for noneconomic reasons	-0.066	-0.173	-10.601*	1.724
	(0.132)	(1.319)	(5.366)	(1.031)
Unemployment	0.269	-0.987***	-2.589	-0.424
	(0.220)	(0.225)	(1.777)	(0.295)
Not in the labor force	0.083	1.262	5.265	0.250
	(0.139)	(0.786)	(4.545)	(0.526)
Ages 25–29				
Employment	-0.314	1.546***	2.608	1.152***
	(0.195)	(0.441)	(1.589)	(0.339)
Full-time employment	-0.515**	1.099***	1.592	0.866**
	(0.238)	(0.325)	(1.156)	(0.293)
Part-time employment for economic reasons	0.192	-2.073***	-3.451	-1.676**
	(0.112)	(0.672)	(2.558)	(0.746)
Part-time employment for noneconomic reasons	0.010	1.722	5.488*	1.097
	(0.080)	(1.557)	(2.932)	(1.452)
Unemployment	0.022	-1.233***	-1.827	-0.987***
	(0.209)	(0.379)	(1.235)	(0.297)
Not in the labor force	0.292	1.923	1.066	2.014
	(0.200)	(1.549)	(4.475)	(1.152)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C2: (continued) Summary: Impacts of elderly employment (ages 66–70) on fertility through labor market outcomes (pooled men and women)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	0.022	1.580*	0.948	0.851*
	(0.189)	(0.786)	(0.978)	(0.445)
Full-time employment	-0.035	1.061**	0.624	0.550**
	(0.177)	(0.402)	(0.624)	(0.224)
Part-time employment	0.038	-2.303**	-0.978	-1.127**
for economic reasons	(0.070)	(0.768)	(1.299)	(0.489)
Part-time employment	0.019	0.239	-1.128	0.043
for noneconomic reasons	(0.084)	(2.354)	(2.381)	(1.165)
Unemployment	-0.011	-1.330**	-0.589	-0.589
	(0.160)	(0.565)	(0.688)	(0.439)
Not in the labor force	-0.011	1.637*	0.355	0.498
	(0.110)	(0.789)	(1.044)	(0.661)
Ages 35–39				
Employment	-0.087	0.723	1.372	0.104
	(0.221)	(0.628)	(0.898)	(0.286)
Full-time employment	-0.021	0.592	1.109*	0.119
	(0.205)	(0.408)	(0.584)	(0.183)
Part-time employment	-0.060	-2.159***	-3.080***	-1.003***
for economic reasons	(0.067)	(0.374)	(0.638)	(0.310)
Part-time employment	-0.006	1.778*	1.642	1.255*
for noneconomic reasons	(0.109)	(0.863)	(1.413)	(0.633)
Unemployment	0.128	-0.871***	-1.278***	-0.504**
	(0.215)	(0.233)	(0.371)	(0.171)
Not in the labor force	-0.041	1.115**	1.383*	0.900***
	(0.132)	(0.389)	(0.649)	(0.222)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C3: Impacts of elderly employment (ages 66–70) on youth employment (men)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-2.567***	-0.715	-0.504	-0.472
	(0.453)	(0.464)	(0.306)	(0.335)
Full-time employment	-3.431***	-1.152*	-0.773**	-0.745
	(0.606)	(0.656)	(0.361)	(0.426)
Part-time employment	0.964***	0.345**	0.295*	0.290*
for economic reasons	(0.147)	(0.135)	(0.161)	(0.164)
Part-time employment	-0.100	0.092	-0.026	-0.017
for noneconomic reasons	(0.107)	(0.202)	(0.139)	(0.152)
Unemployment	1.213***	0.013	0.116	0.154
	(0.317)	(0.340)	(0.302)	(0.295)
Not in the labor force	1.355***	0.702**	0.388**	0.318
	(0.210)	(0.273)	(0.184)	(0.182)
Ages 25–29				
Employment	-1.890***	-0.321	-0.287	-0.226
	(0.348)	(0.312)	(0.338)	(0.382)
Full-time employment	-2.872***	-0.882**	-0.636*	-0.525
	(0.410)	(0.335)	(0.304)	(0.408)
Part-time employment	0.796***	0.341***	0.256***	0.197
for economic reasons	(0.107)	(0.107)	(0.077)	(0.114)
Part-time employment	0.186*	0.220	0.093	0.102
for noneconomic reasons	(0.093)	(0.145)	(0.151)	(0.158)
Unemployment	1.119***	-0.034	0.077	-0.028
	(0.310)	(0.315)	(0.308)	(0.312)
Not in the labor force	0.771***	0.356**	0.211	0.253*
	(0.102)	(0.125)	(0.142)	(0.141)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. $T = 25$. Each coefficient comes from a separate equation for each labor force status. Economic conditions include level of GDP per capita and growth rate of GDP per capita. Occupational composition includes employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years ≥ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C3: (continued) Impacts of elderly employment (ages 66–70) on youth employment (men)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	-1.578***	-0.170	-0.194	-0.044
	(0.299)	(0.191)	(0.209)	(0.218)
Full-time employment	-2.214***	-0.384	-0.257	-0.058
	(0.386)	(0.279)	(0.278)	(0.243)
Part-time employment for economic reasons	0.556***	0.194	0.156	0.072
	(0.097)	(0.117)	(0.101)	(0.080)
Part-time employment for noneconomic reasons	0.080**	0.020	-0.092	-0.057
	(0.035)	(0.063)	(0.069)	(0.079)
Unemployment	1.043***	-0.028	0.229	0.016
	(0.278)	(0.256)	(0.197)	(0.231)
Not in the labor force	0.535***	0.198	-0.035	0.028
	(0.123)	(0.168)	(0.154)	(0.135)
Ages 35–39				
Employment	-1.278***	-0.321**	-0.240*	-0.194
	(0.206)	(0.133)	(0.137)	(0.213)
Full-time employment	-1.857***	-0.577**	-0.437**	-0.179
	(0.285)	(0.216)	(0.183)	(0.250)
Part-time employment for economic reasons	0.581***	0.172**	0.147*	-0.005
	(0.094)	(0.081)	(0.079)	(0.098)
Part-time employment for noneconomic reasons	-0.002	0.084	0.051	-0.009
	(0.034)	(0.066)	(0.072)	(0.091)
Unemployment	1.037***	0.157	0.279	0.235
	(0.228)	(0.205)	(0.186)	(0.275)
Not in the labor force	0.241*	0.165	-0.039	-0.041
	(0.131)	(0.188)	(0.147)	(0.180)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. $T = 25$. Each coefficient comes from a separate equation for each labor force status. Economic conditions include level of GDP per capita and growth rate of GDP per capita. Occupational composition includes employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years ≥ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C4: Summary: Impacts of elderly employment (ages 66–70) on fertility through labor market outcomes (men)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.472	0.606***	1.358	0.296
	(0.335)	(0.152)	(1.188)	(0.212)
Full-time employment	-0.745	0.476***	1.454	0.185
	(0.426)	(0.109)	(0.830)	(0.140)
Part-time employment for economic reasons	0.290*	-1.478***	-5.967**	-0.469
	(0.164)	(0.259)	(2.261)	(0.342)
Part-time employment for noneconomic reasons	-0.017	0.250	-2.883	0.765
	(0.152)	(0.999)	(4.411)	(0.870)
Unemployment	0.154	-0.621***	-1.781	-0.237
	(0.295)	(0.157)	(1.312)	(0.209)
Not in the labor force	0.318	-0.891	-0.407	-0.707
	(0.182)	(0.596)	(2.042)	(0.437)
Ages 25–29				
Employment	-0.226	0.780***	1.357	0.549***
	(0.382)	(0.220)	(0.786)	(0.171)
Full-time employment	-0.525	0.762***	1.228*	0.513***
	(0.408)	(0.150)	(0.648)	(0.140)
Part-time employment for economic reasons	0.197	-1.695**	-3.227	-1.236
	(0.114)	(0.612)	(2.172)	(0.710)
Part-time employment for noneconomic reasons	0.102	-0.317	1.139	0.142
	(0.158)	(1.089)	(2.499)	(1.002)
Unemployment	-0.028	-0.867***	-1.548*	-0.614***
	(0.312)	(0.271)	(0.839)	(0.195)
Not in the labor force	0.253*	-1.436***	-2.179	-0.985
	(0.141)	(0.452)	(2.183)	(0.636)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. All regressions in columns 3–5 include real GDP growth rate, women's employment share, population share of married, higher education level (education year $\geq$ 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C4: (continued) Summary: Impacts of elderly employment (ages 66–70) on fertility through labor market outcomes (men)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	-0.044	0.758*	0.471	0.423*
	(0.218)	(0.391)	(0.470)	(0.216)
Full-time employment	-0.058	0.555**	0.249	0.331**
	(0.243)	(0.255)	(0.366)	(0.140)
Part-time employment for economic reasons	0.072	-1.652**	-0.674	-0.758*
	(0.080)	(0.614)	(0.956)	(0.369)
Part-time employment for noneconomic reasons	-0.057	5.129**	6.323***	-0.892
	(0.079)	(1.813)	(2.079)	(1.714)
Unemployment	0.016	-0.732*	-0.131	-0.335
	(0.231)	(0.346)	(0.442)	(0.277)
Not in the labor force	0.028	-0.030	-0.959	-0.231
	(0.135)	(0.572)	(0.604)	(0.363)
Ages 35–39				
Employment	-0.194	0.345	0.649	0.041
	(0.213)	(0.303)	(0.434)	(0.136)
Full-time employment	-0.179	0.384	0.620*	0.124
	(0.250)	(0.247)	(0.350)	(0.121)
Part-time employment for economic reasons	-0.005	-1.863***	-2.427***	-1.135***
	(0.098)	(0.353)	(0.688)	(0.268)
Part-time employment for noneconomic reasons	-0.009	1.699	2.578	0.961
	(0.091)	(1.174)	(1.590)	(0.787)
Unemployment	0.235	-0.578**	-0.841**	-0.336**
	(0.275)	(0.214)	(0.308)	(0.140)
Not in the labor force	-0.041	0.504	0.428	0.627**
	(0.180)	(0.401)	(0.544)	(0.218)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. All regressions in columns 3–5 include real GDP growth rate, women's employment share, population share of married, higher education level (education year $\geq$ 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C5: Impacts of elderly employment (ages 66–70) on youth employment (women)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-1.831***	-0.089	-0.202	-0.233
	(0.373)	(0.174)	(0.162)	(0.168)
Full-time employment	-2.599***	-0.385*	-0.347	-0.366
	(0.434)	(0.188)	(0.237)	(0.248)
Part-time employment for economic reasons	0.985***	0.363***	0.295**	0.247*
	(0.126)	(0.114)	(0.140)	(0.138)
Part-time employment for noneconomic reasons	-0.217**	-0.067	-0.151	-0.113
	(0.094)	(0.153)	(0.189)	(0.190)
Unemployment	0.829***	0.159	0.331	0.381**
	(0.215)	(0.254)	(0.258)	(0.158)
Not in the labor force	1.002***	-0.070	-0.128	-0.148
	(0.300)	(0.289)	(0.295)	(0.240)
Ages 25–29				
Employment	-1.380***	0.130	-0.076	-0.384
	(0.358)	(0.373)	(0.242)	(0.243)
Full-time employment	-1.803***	-0.103	-0.181	-0.481**
	(0.357)	(0.279)	(0.246)	(0.213)
Part-time employment for economic reasons	0.672***	0.261**	0.223**	0.187
	(0.094)	(0.098)	(0.093)	(0.137)
Part-time employment for noneconomic reasons	-0.249***	-0.028	-0.118	-0.090
	(0.086)	(0.111)	(0.101)	(0.114)
Unemployment	0.606***	-0.031	0.053	0.073
	(0.146)	(0.133)	(0.132)	(0.182)
Not in the labor force	0.774**	-0.099	0.023	0.310
	(0.285)	(0.386)	(0.257)	(0.359)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. T = 25. Each coefficient comes from a separate equation for each labor force status. Economic conditions include level of GDP per capita and growth rate of GDP per capita. Occupational composition includes employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years $\geq$ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C5: (continued) Impacts of elderly employment (ages 66–70) on youth employment (women)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	-1.044***	0.211	0.117	0.102
	(0.298)	(0.288)	(0.274)	(0.239)
Full-time employment	-1.090***	0.234	0.067	0.012
	(0.294)	(0.278)	(0.228)	(0.233)
Part-time employment for economic reasons	0.488***	0.129	0.086	0.005
	(0.093)	(0.097)	(0.116)	(0.110)
Part-time employment for noneconomic reasons	-0.443***	-0.153	-0.036	0.084
	(0.094)	(0.125)	(0.113)	(0.120)
Unemployment	0.681***	0.046	0.110	-0.035
	(0.161)	(0.147)	(0.145)	(0.137)
Not in the labor force	0.363*	-0.256	-0.227	-0.067
	(0.179)	(0.220)	(0.221)	(0.185)
Ages 35–39				
Employment	-0.940***	-0.089	-0.113	0.001
	(0.196)	(0.195)	(0.216)	(0.317)
Full-time employment	-0.906***	-0.029	-0.052	0.100
	(0.199)	(0.193)	(0.181)	(0.305)
Part-time employment for economic reasons	0.476***	0.114	0.080	-0.113
	(0.096)	(0.075)	(0.083)	(0.093)
Part-time employment for noneconomic reasons	-0.510***	-0.174	-0.141	0.013
	(0.109)	(0.132)	(0.118)	(0.175)
Unemployment	0.673***	0.126	0.114	0.024
	(0.161)	(0.189)	(0.195)	(0.231)
Not in the labor force	0.266*	-0.037	-0.001	-0.025
	(0.140)	(0.224)	(0.201)	(0.206)
Economic Conditions	Yes	Yes	Yes	Yes
Manufacturing Emp Share		Yes	Yes	Yes
Occupational Composition			Yes	Yes
Population Composition				Yes

Note. $T = 25$. Each coefficient comes from a separate equation for each labor force status. Economic conditions include level of GDP per capita and growth rate of GDP per capita. Occupational composition includes employment share of routine occupations and index for possible offshoring. Population composition includes population share of higher education level (education years ≥ 16), Black, Other, and Hispanic. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C6: Summary: Impact of elderly employment (ages 66–70) on fertility through labor market outcomes (women)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.233	0.667**	-0.507	0.753*
	(0.168)	(0.247)	(1.789)	(0.350)
Full-time employment	-0.366	0.614	2.876*	0.221
	(0.248)	(0.351)	(1.529)	(0.451)
Part-time employment for economic reasons	0.247*	-1.037	-8.606**	0.035
	(0.138)	(0.666)	(3.474)	(0.963)
Part-time employment for noneconomic reasons	-0.113	0.722	-3.270	1.257**
	(0.190)	(0.584)	(2.730)	(0.470)
Unemployment	0.381**	-2.291***	-3.915	-1.465
	(0.158)	(0.600)	(4.589)	(0.886)
Not in the labor force	-0.148	-0.338	1.163	-0.562
	(0.240)	(0.391)	(1.988)	(0.399)
Ages 25–29				
Employment	-0.384	-0.511	-0.993	-0.169
	(0.243)	(0.347)	(1.169)	(0.233)
Full-time employment	-0.481**	-0.507**	-1.169	-0.089
	(0.213)	(0.231)	(0.778)	(0.243)
Part-time employment for economic reasons	0.187	0.031	1.479	-0.817
	(0.137)	(0.799)	(2.522)	(1.425)
Part-time employment for noneconomic reasons	-0.090	1.302	2.869	0.477
	(0.114)	(0.885)	(2.123)	(0.842)
Unemployment	0.073	-0.524	2.966	-1.628*
	(0.182)	(0.622)	(2.511)	(0.852)
Not in the labor force	0.310	0.491	0.329	0.391
	(0.359)	(0.325)	(1.148)	(0.302)

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. All regressions in columns 3–5 include real GDP growth rate, men's employment share, population share of married, higher education level (education year >= 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C6: (continued) Summary: Impact of elderly employment (ages 66–70) on fertility through labor market outcomes (women)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	0.102	-0.306	0.362	-0.164
	(0.239)	(0.600)	(0.809)	(0.359)
Full-time employment	0.012	0.272	0.915	-0.005
	(0.233)	(0.465)	(0.687)	(0.384)
Part-time employment for economic reasons	0.005	-1.806	-0.419	-0.953
	(0.110)	(1.294)	(1.734)	(0.853)
Part-time employment for noneconomic reasons	0.084	-1.142	-2.087	-0.043
	(0.120)	(1.321)	(1.191)	(0.648)
Unemployment	-0.035	-1.465**	-1.546	-0.440
	(0.137)	(0.648)	(0.922)	(0.472)
Not in the labor force	-0.067	0.871	0.301	0.327
	(0.185)	(0.512)	(0.737)	(0.378)
Ages 35–39				
Employment	0.001	-0.227	-0.487	0.288
	(0.317)	(0.385)	(0.523)	(0.214)
Full-time employment	0.100	-0.171	-0.011	0.035
	(0.305)	(0.458)	(0.612)	(0.274)
Part-time employment for economic reasons	-0.113	-2.098***	-3.000***	-0.696
	(0.093)	(0.524)	(0.582)	(0.516)
Part-time employment for noneconomic reasons	0.013	0.641	0.279	0.734**
	(0.175)	(0.595)	(0.923)	(0.330)
Unemployment	0.024	-0.733**	-0.944*	-0.670***
	(0.231)	(0.336)	(0.494)	(0.214)
Not in the labor force	-0.025	0.702**	1.055**	0.256
	(0.206)	(0.276)	(0.386)	(0.220)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. All regressions in columns 3–5 include real GDP growth rate, men's employment share, population share of married, higher education level (education year >= 16), Black, Other, Hispanic, and time trends. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.C7: Summary: Impact of elderly employment (ages 66–70) on fertility through labor market outcomes at state level

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.049**	0.180***	0.445	0.141
	(0.020)	(0.065)	(1.340)	(0.113)
Unemployment	-0.012	-0.162*	1.427	0.014
	(0.012)	(0.093)	(2.056)	(0.147)
Not in the labor force	0.061***	-0.077*	-1.299	-0.137
	(0.021)	(0.045)	(1.436)	(0.107)
Ages 25–29				
Employment	0.005	0.046	0.794**	0.166
	(0.024)	(0.095)	(0.307)	(0.152)
Unemployment	-0.017	-0.113	-1.470***	-0.279
	(0.014)	(0.086)	(0.484)	(0.173)
Not in the labor force	0.011	0.029	0.191	0.019
	(0.020)	(0.084)	(0.361)	(0.161)
Ages 30–34				
Employment	0.010	0.070	0.538***	0.013
	(0.022)	(0.069)	(0.190)	(0.114)
Unemployment	-0.022*	-0.068	0.256	0.270*
	(0.013)	(0.074)	(0.227)	(0.135)
Not in the labor force	0.012	-0.026	-0.892***	-0.279**
	(0.017)	(0.069)	(0.189)	(0.129)
Ages 35–39				
Employment	0.022	0.030	0.350***	0.142**
	(0.019)	(0.028)	(0.080)	(0.068)
Unemployment	-0.014	-0.018	-0.003	-0.066
	(0.010)	(0.037)	(0.105)	(0.088)
Not in the labor force	-0.006	-0.017	-0.364***	-0.108
	(0.018)	(0.019)	(0.090)	(0.066)

Note. N = 1,275 (51 states * 25 years). All three labor force statuses (employment, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate equation for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on conception by all women, conception by married women, and conception by unmarried women, respectively. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Appendix D. Supplemental Analysis

2.D1 Impact of elderly employment (ages 66–70) on marriage

I supplementally analyzed the extent to which retirement delays among older people aged 66–70 influenced young adult marriage through changes in employment status of the young. Like childbirth, labor market outcomes strongly relate to the decision to marry. For analysis, I used the following equation:

$$MARRIAGERATE_t = \beta_0 + \beta_1 * Y_t + X_{1,t}\beta_2 + T + T^2 + T^3 + \varepsilon_t \tag{2.7}$$

which is almost equivalent to equation (2.2) in Section 2.4.1. $MARRIAGERATE$ is the number of married people by age group divided by the total number in each respective age group multiplied by 100. I used three types of marriage rate: (a) marriage rate for both men and women, (b) marriage rate for men, and (c) marriage rate for women, calculated using the ASES of CPS. Subscript t represents the year (1994–2018). Y represents the rates of five variables related to employment status of young adults. I regressed this equation for four age groups (i.e., 20–24, 25–29, 30–34, and 35–39).

To control for changes in marriage due to economic fluctuation, I included real GDP growth in the equation. I also controlled for race (i.e., Black, Hispanic, and Other) and high education level (i.e., college degree or higher). Additionally, to account for secular trends in fertility, I added time trends denoted as T, T^2, and T^3.

For analysis at the state level, I divided youth employment status into only three categories: (a) employment, (b) unemployment, and (c) not in the labor force. I also included state and year fixed effects. Control variables were the same as those used in time-series analysis, but I aggregated the variables at the state level.

Table 2.D1: Summary: Impacts of elderly employment (ages 66–70) on marriage through labor market outcomes (pooled men and women)

	(1)	(2)	(3)	(4)
Ages 20–24				
Employment	-0.352*	0.076	0.017	0.146
	(0.177)	(0.076)	(0.050)	(0.117)
Full-time employment	-0.554*	0.063	0.048	0.085
	(0.285)	(0.072)	(0.056)	(0.108)
Part-time employment for economic reasons	0.268*	-0.094	-0.109	-0.097
	(0.147)	(0.226)	(0.176)	(0.330)
Part-time employment for noneconomic reasons	-0.066	-0.273	-0.736	0.243
	(0.132)	(0.426)	(0.422)	(0.458)
Unemployment	0.269	-0.079	-0.046	-0.127
	(0.220)	(0.116)	(0.083)	(0.177)
Not in the labor force	0.083	-0.108	0.091	-0.314
	(0.139)	(0.198)	(0.189)	(0.234)
Ages 25–29				
Employment	-0.314	0.138	0.282	-0.009
	(0.195)	(0.116)	(0.165)	(0.087)
Full-time employment	-0.515**	0.110	0.211	0.005
	(0.238)	(0.095)	(0.130)	(0.075)
Part-time employment for economic reasons	0.192	-0.093	-0.302	0.094
	(0.112)	(0.339)	(0.473)	(0.243)
Part-time employment for noneconomic reasons	0.010	-0.163	0.259	-0.511
	(0.080)	(0.502)	(0.689)	(0.363)
Unemployment	0.022	-0.010	-0.078	0.049
	(0.209)	(0.187)	(0.252)	(0.132)
Not in the labor force	0.292	-0.396**	-0.711***	-0.055
	(0.200)	(0.163)	(0.219)	(0.145)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on marriage rate for both men and women, marriage rate for men, and marriage rate for women, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D1: (continued) Summary: Impact of elderly employment (ages 66–70) on marriage through labor market outcomes (pooled men and women)

	(1)	(2)	(3)	(4)
Ages 30–34				
Employment	0.022	0.237	0.405*	0.074
	(0.189)	(0.142)	(0.198)	(0.118)
Full-time employment	-0.035	0.174	0.289*	0.063
	(0.177)	(0.106)	(0.153)	(0.085)
Part-time employment	0.038	-0.427	-0.703	-0.164
for economic reasons	(0.070)	(0.373)	(0.507)	(0.319)
Part-time employment	0.019	0.201	0.682	-0.293
for noneconomic reasons	(0.084)	(1.169)	(1.514)	(1.029)
Unemployment	-0.011	-0.254	-0.421	-0.092
	(0.160)	(0.183)	(0.251)	(0.151)
Not in the labor force	-0.011	-0.442	-0.815	-0.075
	(0.110)	(0.428)	(0.572)	(0.365)
Ages 35–39				
Employment	-0.087	0.113	0.177	0.048
	(0.221)	(0.171)	(0.269)	(0.151)
Full-time employment	-0.021	0.175	0.275	0.076
	(0.205)	(0.144)	(0.224)	(0.133)
Part-time employment	-0.060	-0.434	-0.239	-0.622
for economic reasons	(0.067)	(0.525)	(0.811)	(0.447)
Part-time employment	-0.006	-0.379	-1.258**	0.479
for noneconomic reasons	(0.109)	(0.460)	(0.546)	(0.510)
Unemployment	0.128	-0.008	0.108	-0.121
	(0.215)	(0.173)	(0.288)	(0.139)
Not in the labor force	-0.041	-0.259	-0.741**	0.216
	(0.132)	(0.256)	(0.330)	(0.265)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. (1) represents the effects of elderly employment (ages 66–70) on youth employment, including all control variables (economic conditions, manufacturing employment share, occupation composition, and population composition). (2), (3), and (4) display the effects of changes in employment status of young adults on marriage rate for both men and women, marriage rate for men, and marriage rate for women, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D2: Summary: Impacts of elderly employment (ages 66–70) on marriage (men) through labor market outcomes (men)

	Elderly Employment → Youth Employment (men)	Youth Employment → Marriage Rate (men)
Ages 20–24		
Employment	-0.472	0.026
	(0.335)	(0.051)
Full-time employment	-0.745	0.038
	(0.426)	(0.045)
Part-time employment for economic reasons	0.290*	-0.056
	(0.164)	(0.156)
Part-time employment for noneconomic reasons	-0.017	-0.736**
	(0.152)	(0.326)
Unemployment	0.154	-0.030
	(0.295)	(0.067)
Not in the labor force	0.318	-0.053
	(0.182)	(0.132)
Ages 25–29		
Employment	-0.226	0.136
	(0.382)	(0.125)
Full-time employment	-0.525	0.097
	(0.408)	(0.115)
Part-time employment for economic reasons	0.197	-0.109
	(0.114)	(0.452)
Part-time employment for noneconomic reasons	0.102	0.238
	(0.158)	(0.446)
Unemployment	-0.028	-0.048
	(0.312)	(0.189)
Not in the labor force	0.253*	-0.647**
	(0.141)	(0.284)

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D2: (continued) Summary: Impact of elderly employment (ages 66–70) on marriage (men) through labor market outcomes (men)

	Elderly Employment → Youth Employment (men)	Youth Employment → Marriage Rate (men)
Ages 30–34		
Employment	-0.044	0.326*
	(0.218)	(0.169)
Full-time employment	-0.058	0.232*
	(0.243)	(0.117)
Part-time employment for economic reasons	0.072	-0.570
	(0.080)	(0.367)
Part-time employment for noneconomic reasons	-0.057	-2.825**
	(0.079)	(0.967)
Unemployment	0.016	-0.290
	(0.231)	(0.184)
Not in the labor force	0.028	-0.732
	(0.135)	(0.466)
Ages 35–39		
Employment	-0.194	0.154
	(0.213)	(0.192)
Full-time employment	-0.179	0.097
	(0.250)	(0.170)
Part-time employment for economic reasons	-0.005	0.095
	(0.098)	(0.614)
Part-time employment for noneconomic reasons	-0.009	0.188
	(0.091)	(1.427)
Unemployment	0.235	0.145
	(0.275)	(0.186)
Not in the labor force	-0.041	-0.885***
	(0.180)	(0.242)

Note. $T = 25$. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D3: Summary: Impact of elderly employment (ages 66–70) on marriage (women) through labor market outcomes (women)

	Elderly Employment → Youth Employment (women)	Youth Employment → Marriage Rate (women)
Ages 20–24		
Employment	-0.233	0.188**
	(0.168)	(0.088)
Full-time employment	-0.366	0.080
	(0.248)	(0.158)
Part-time employment	0.247*	-0.155
for economic reasons	(0.138)	(0.330)
Part-time employment	-0.113	0.440**
for noneconomic reasons	(0.190)	(0.198)
Unemployment	0.381**	-0.221
	(0.158)	(0.189)
Not in the labor force	-0.148	-0.095
	(0.240)	(0.176)
Ages 25–29		
Employment	-0.384	0.030
	(0.243)	(0.092)
Full-time employment	-0.481**	0.045
	(0.213)	(0.072)
Part-time employment	0.187	0.018
for economic reasons	(0.137)	(0.205)
Part-time employment	-0.090	-0.335
for noneconomic reasons	(0.114)	(0.259)
Unemployment	0.073	0.019
	(0.182)	(0.169)
Not in the labor force	0.310	-0.046
	(0.359)	(0.099)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D3: (continued) Summary: Impact of elderly employment (ages 66–70) on marriage (women) through labor market outcomes (women)

	Elderly Employment → Youth Employment (women)	Youth Employment → Marriage Rate (women)
Ages 30–34		
Employment	0.102	0.108
	(0.239)	(0.156)
Full-time employment	0.012	0.027
	(0.233)	(0.144)
Part-time employment for economic reasons	0.005	-0.053
	(0.110)	(0.413)
Part-time employment for noneconomic reasons	0.084	0.584
	(0.120)	(0.379)
Unemployment	-0.035	-0.217
	(0.137)	(0.236)
Not in the labor force	-0.067	0.015
	(0.185)	(0.367)
Ages 35–39		
Employment	0.001	0.055
	(0.317)	(0.192)
Full-time employment	0.100	0.040
	(0.305)	(0.163)
Part-time employment for economic reasons	-0.113	-0.418
	(0.093)	(0.362)
Part-time employment for noneconomic reasons	0.013	0.286
	(0.175)	(0.313)
Unemployment	0.024	-0.197
	(0.231)	(0.163)
Not in the labor force	-0.025	0.159
	(0.206)	(0.191)

Note. T = 25. All five labor force statuses (full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate regression for each labor force status. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D4: Summary: Impact of elderly employment (ages 66–70) on marriage through labor market outcomes at state level

	Elderly Employment → Youth Employment	Youth Employment → Marriage Rate
Ages 20–24		
Employment	-0.049**	0.005
	(0.020)	(0.034)
Unemployment	-0.012	-0.063
	(0.012)	(0.053)
Not in the labor force	0.061***	0.018
	(0.021)	(0.039)
Ages 25–29		
Employment	0.005	0.048
	(0.024)	(0.040)
Unemployment	-0.017	-0.187**
	(0.014)	(0.078)
Not in the labor force	0.011	0.018
	(0.020)	(0.049)
Ages 30–34		
Employment	0.010	0.072
	(0.022)	(0.054)
Unemployment	-0.022*	-0.214***
	(0.013)	(0.079)
Not in the labor force	0.012	-0.012
	(0.017)	(0.062)
Ages 35–39		
Employment	0.022	0.088**
	(0.019)	(0.043)
Unemployment	-0.014	-0.333***
	(0.010)	(0.085)
Not in the labor force	-0.006	0.020
	(0.018)	(0.050)

Note. N = 1,275 (51 states * 25 years). All three labor force statuses (employment, unemployment, and not in the labor force) add up to 100%. Each coefficient comes from a separate equation for each labor force status. Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

2.D2 The impacts of elderly employment (ages 66–70) on fertility: using Structural Equation Modeling (SEM)

I used SEM to derive the effects of elderly employment (ages 66–70) on fertility using employment status type (i.e., full-time employment, part-time employment for economic reasons, part-time employment for noneconomic reasons, unemployment, and not in the labor force) as the mediator. Through this method, I obtained a sole total effect of elderly employment on fertility in a certain age group (see Section 2.5). However, this total effect derives from two effects: effects of elderly employment on youth employment status and effects of youth employment status on childbirth (see Section 2.4).

For example, to analyze the effect of older workers on fertility in age group 20–24, the method used in Section 2.4 required a total of 10 regressions. Five were for analyzing the effects of older workers on the five employment status types and the remaining five regressions were for analyzing the effects of the five employment status types on childbirth in age group 20–24. On the contrary, when using SEM, one regression was sufficient to analyze the effect of older workers on childbirth in age group 20–24, considering all pathways for each employment status. Compared to the method used in Section 2.4, this method cannot identify the effect of a specific path that is statistically significant and clear, but its advantage over the reduced form used in Section 2.5 is the derivation of the total effect by considering the impact of all pathways on the variable of interest.

Table 2.D5: Impact of elderly employment (ages 66–70) on fertility: using SEM

	Conception Rate			
Age group	20–24	25–29	30–34	35–39
Panel A. All				
Elderly employment[a]	-0.551**	-0.583	-0.092	0.315
	(0.225)	(0.461)	(0.113)	(0.233)
Elderly employment[b]	-0.646***	-0.590	-0.398	0.067
	(0.220)	(0.304)	(0.278)	(0.185)
Elderly employment[c]	-0.862***	-0.088	-0.163	0.124
	(0.247)	(0.298)	(0.211)	(0.148)
Panel B. Married				
Elderly employment[a]	-1.694	-2.094	-0.026	0.442
	(1.528)	(1.504)	(0.125)	(0.323)
Elderly employment[b]	-2.350**	-0.714	-0.537	0.024
	(1.124)	(0.826)	(0.444)	(0.212)
Elderly employment[c]	-1.495	-0.157	-0.181	0.255
	(1.766)	(0.735)	(0.257)	(0.213)
Panel C. Unmarried				
Elderly employment[a]	-0.334	-0.184	-0.036	0.039
	(0.255)	(0.396)	(0.057)	(0.113)
Elderly employment[b]	-0.292**	-0.357	0.008	0.038
	(0.145)	(0.214)	(0.128)	(0.128)
Elderly employment[c]	-0.539**	-0.144	-0.033	-0.048
	(0.235)	(0.341)	(0.083)	(0.140)

Note. $T = 25$. Superscript 'a' means that the results were derived using employment status type calculated by pooling men and women as the mediator. Superscripts 'b' and 'c' mean that the results were derived using employment status type for men and for women as the mediator, respectively. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2.D6: Impact of elderly employment (ages 66–70) on fertility at state level: using SEM

	Conception Rate			
Age group	20–24	25–29	30–34	35–39
Panel A. All				
Elderly employment	-0.007	0.002	0.001	0.001
	(0.005)	(0.002)	(0.002)	(0.001)
Panel B. Married				
Elderly employment	-0.069	0.025	-0.009	0.006
	(0.088)	(0.019)	(0.016)	(0.007)
Panel C. Unmarried				
Elderly employment	-0.009	0.005	-0.007	0.003
	(0.007)	(0.005)	(0.005)	(0.003)

Note. N = 1,275 (51 states * 25 years). Robust standard errors in parentheses are clustered on state. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Chapter 3

How Does Underemployment Affect Marriage and Childbirth among Young Adults?

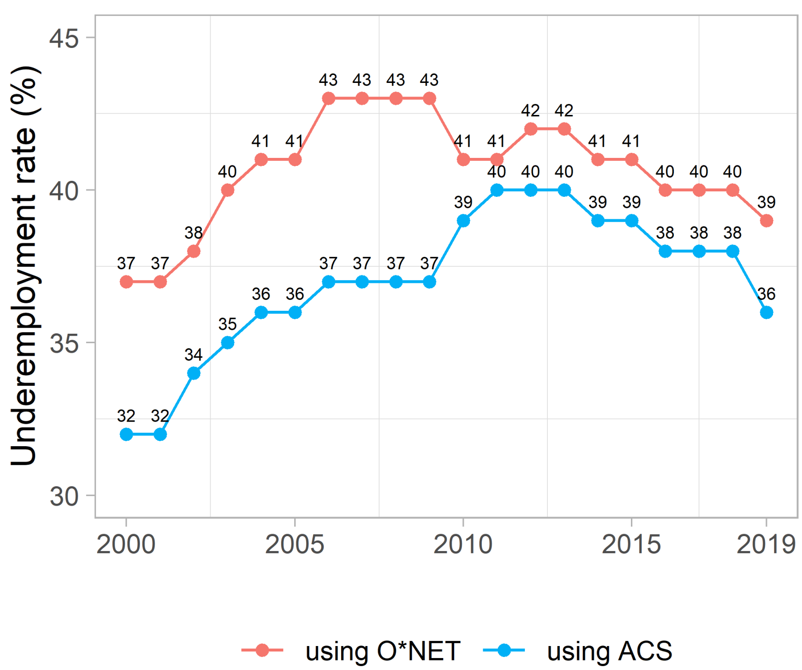
3.1 Introduction

One of the issues related to labor market outcomes for young adults is underemployment, a phenomenon more commonly known as overeducation. In this study, I used the term "underemployment" rather than "overeducation" because I considered underemployment another type of employment status in a labor market. Underemployment refers to the condition of having a level of education higher than required to perform a specific job (McGuinness, 2006). Focusing on the effects of underemployment among college graduates, I narrowed down the definition of underemployment: a phenomenon in which 4-year college graduates gain employment in a job that does not require that degree (Abel et al., 2014).

Indeed, facing underemployment might be inevitable for young adults who recently graduated as the first step in a career path due to a variety of higher educational opportunities. The number of jobs requiring a Bachelor's degree is unlikely to increase in proportion to growing opportunities for higher education due to relatively low and stable economic growth, especially in developed countries. Thus, European countries naturally pay much attention to underemployment among college graduates (Baert et al., 2013; Meroni and Vera-Toscano, 2017; Voces and Caínzos, 2020).

The phenomenon of underemployment in the United States has gained more attention since the 2001 recession (Abel et al., 2014; Clark et al., 2017). Abel et al. (2014) showed that the underemployment rates for recent college graduates – those aged 22 to 27 with a Bachelor's degree or higher – reached about 40% from 1990 to 2012 based on the Current Population Survey (CPS) and the Occupational Information Network (O*NET) of the U.S. Department of Labor. Figure 3.1 shows the underemployment rate from 2000 to 2019, which I computed using only those who graduated from a 4-year college. Although the underemployment rate differs slightly depending on the criteria for judging underemployment, the result is similar to that of Abel et al. (2014). Even though the rates have declined since 2014, underemployment remains an important issue in the labor market because about 40% of college graduates start work in an underemployed state.

Figure 3.1: Underemployment rate for 4-year college graduates aged 21 to 30



Data. 2000–2019 American Community Survey and O*NET 14.
Note. The underemployment rate is the ratio of the number of 4-year college graduates underemployed to the total number of 4-year college graduates employed. To compute the yearly underemployment rate, I restricted the sample to ages 21–30. I weighted individuals using personal weights provided by data sources. The orange line represents the underemployment rate calculated using the required education level from O*NET as a criterion for judging underemployment. The blue line represents the underemployment rate based on the definition of the required education for each occupation as the most frequently observed education level by occupation using ACS.

In sociology, underemployment is a specific form of status inconsistency, and scholars have explored whether underemployment affects job or life satisfaction (Ahmed Lahsen et al., 2020; Bedemariam and Ramos, 2021; Burris, 1983; Peiró et al., 2010; Piper, 2015; Ueno and Krause, 2018; Voces and Caínzos, 2020) and subjective well-being (Maynard et al., 2006; Voces and Caínzos, 2020). In addition, in support of labor market policies for young adults, researchers have conducted studies about whether underemployment at an early stage in a labor market might be preferable to remaining unemployed for young adults trying to build a career (i.e., whether underemployment is a stepping stone to the next job or just a trap) (Baert et al., 2013; Meroni and Vera-Toscano, 2017).

While scholars have conducted studies on the impacts of underemployment on individual well-being and future career, few have examined the impacts of underemployment on marriage and childbirth among young adults. Underemployment is a type of job instability, similar to unemployment or part-time employment, because it usually entails a decrease in expected real wage earnings (Brynin, 2002; Montt, 2017). Given that fertility highly relates to labor market outcomes, the lack of studies on the effect of underemployment on marriage and childbirth is somewhat surprising, especially considering that scholars have examined the effects of unemployment or other types of job instability on childbirth (Adsera, 2005; Cazzola et al., 2016; Autor et al., 2019; Bono et al., 2015; Currie and Schwandt, 2014; Kravdal, 2002; Mocan, 1990).

To fill this gap, I examined whether underemployment at the start of a career affects future marriage and childbirth using the National Longitudinal Surveys of Youth data starting in 1997 (NLSY97). Before conducting the main analyses, I investigated which factors relate to initial underemployment status in a labor market. Using cross-sectional analysis, I then analyzed the effect of underemployment n years after graduation on marriage in the same year and childbirth in the following year. Because I constructed occupational, marital, and childbirth history using a 10-year period after graduation of each cohort, this cross-sectional analysis allowed me to track the short-term effect of underemployment on marriage and childbirth in each year. By doing so, I could also examine whether employment status affected marriage and childbirth differently as the cohorts aged, given that marriage and childbirth closely related to age and that people made decisions at each point in time based on their current situation and their entire life cycle. In cross-sectional analysis, one challenge is to deal with the issue of endogeneity caused by unobserved individual factors that might make the underemployed less likely to marry and have a child. To address this issue, I used panel analysis to control for unobserved characteristics as a fixed effect, another way to see the short-term effect of underemployment on marriage and childbirth.

To analyze the persistence of underemployment at the beginning of a career, I used the Kaplan-Meier estimation method and a proportional hazard model with time-invariant variables. To link how underemployment, as the initial labor market outcome, might affect marriage and childbirth, I first investigated whether underemployment at an early stage of labor market participation affected future labor market outcomes.

In analyzing underemployment, the analysis itself is important, but determining who is underemployed is equally important because the same person might have a different status depending on the assessment criteria. Generally, methods for measuring underemployment fall into three categories: (a) workers' self-assessment (WA, a subjective measure), (b) job analysis (JA, an objective measure), and (c) realized matches (RM, a statistical measure). The first method is based on the individual's responses to a question about whether one's level of education is adequate for one's job. The second method is based on information provided by job experts who analyze the "required" level of education for a certain job. The third method compares the worker's attained education to a statistical threshold (e.g., mean and mode). In this study, I first took the second approach using the O*NET information in Section 3.4. To check robustness, I then used the most frequently observed education level in each occupation from American Community Survey (ACS) and conducted exactly the same analysis performed in Section 3.4.

First, I found that being underemployed at the start of a career highly related to grades and major. The higher one's grades, the lower the probability of obtaining an underemployed job in the first place. The probability of being underemployed differed based on major for both men and women. However, the majors that negatively or positively related to underemployment differed by gender. Second, I did not find any evidence that underemployment prevented marriage and childbirth in the short term, and I also did not see different patterns in marriage and childbirth according to underemployment status as age increased. Third, even in panel analysis, I confirmed underemployment did not relate to marriage and childbirth. Fourth, through hazard model analysis, I found that underemployment persistently and negatively affected future labor market outcomes for both men and women and that this effect was more pronounced for men. I also found that, at least for women, underemployment at the beginning negatively related to having a first child, even though it did not relate to marriage for either men or women or to childbirth for men. Fifth, with a statistical approach to judge underemployment, I found the following: (a) for men, the probability of being underemployed in their first job related to race, major, and parents' educational background, and for women, the probability related to grades, major, and parents' educational background, (b) underemployed men at the starting point in their career were more likely to remain persistently underemployed, but initially underemployed women were not, and (c) no evidence that underemployment harmed marriage and childbirth in the short and long term for both men and women.

The findings of this study make two important contributions. First, I examined which factors relate to being underemployed in the first job. That grades and major related to underemployment suggests that underemployment is partially dependent on individual attributes and operates to some extent based on Assignment Theory (Sattinger, 1993). Second, to the best of my knowledge, I am the first to analyze the effect of underemployment on marriage and childbirth. Although I obtained the results with only a small number of samples, the findings are a catalyst for future research using various datasets.

The remainder of the paper is organized as follows. Section 3.2 briefly summarizes previous literature in three relevant areas. Section 3.3 introduces the data, and Section 3.4 describes the empirical results. Section 3.5 presents the robustness check. Section 3.6 documents issues worth discussing based on the results, and Section 3.7 summarizes the findings.

3.2 Literature Review

3.2.1 Wage penalty of underemployment

Interest in underemployment (i.e., overeducation) in labor economics started with a decrease in the returns of education over time, leading to a study about the existence of a wage penalty for the overeducated.[1] Based on U.S. data, Clark et al. (2017) found that the wages of non-overeducated workers who had worked as an overeducated in the past were about 2.6–4.2% lower than those who had not worked previously. They also found that this sizeable wage penalty persisted over 4 years. Using Spanish data, Hernandez and Serrano (2012) found a 28% difference in the gross hourly wage between overqualified and well-matched employees. They showed that among the total difference, only 3 percentage points related to the characteristics of the individuals and their workplace. The remaining 25 percentage points corresponded to a discrimination effect. Bahl and Sharman (2021) analyzed wage/salaried workers ages 15–59 in India. They found that overeducated workers experienced a wage penalty of 7% compared to their counterparts who had an adequate education level. Many researchers have confirmed evidence of lower wages for overeducated workers in other countries, such as Argentina (De Santis et al., 2022) and Thailand (Vivatsurakit and Vechbanyongratana, 2021).

Using cross-sectional data in Australia, Sloane and Mavromars (Sloane, 2020) found a significant wage penalty – over 20% – for overeducated college graduates. However, in the same study, they showed that a significant negative association between overeducation and wage penalty almost disappeared in a panel regression, controlling for unobserved individual characteristics. They emphasized the importance of obtaining appropriate data when analyzing a causal relationship between overeducation and wages: panel data that controls for unobserved individual factors by providing longitudinal information about a cohort of individuals. Using data from the Panel Study of Income Dynamics in the United States, Yuping Tsai (2010) found that overeducation

[1] For a comprehensive review of the concept, measurement method, and incidence of overeducation, see Flisi et al. (2017) and Queralt Capsada-Munsech (2019). For an extensive review of the theoretical framework explaining the existence of overeducation, see Seamus McGuinness (2006) and Queralt Capsada-Munsech (2017).

did not relate to lower earnings. Like Sloane and Mavromars (Sloane, 2020), Yuping Tsai (2010) concluded that a difference between the finding in her study and the significant wage differential between the overeducated and non-overeducated found in previous studies was primarily due to the non-random sample of workers in the previous studies.

In contrast, Marta Palczynska (2021) found that accounting for personality and cognitive skills – regarded as unobserved individual factors that raise the risk of being overeducated and, thus, earning lower wages – did not change the magnitude or significance of the overeducation wage penalty estimates using data from the Polish Follow-up Study to the Programme for International Assessment of Adult Competencies (postPIAAC). She found that including cognitive and non-cognitive skills led to only a minor reduction in the overeducation wage penalty for people aged 18–29 with secondary education: from 15.1% to 13.3% in the OLS model and from 12.8% to 10.3% in the Propensity Score Matching model (no change in statistical significance).

3.2.2 Persistence of underemployment

Clark et al. (2017) analyzed career dynamics (i.e., transitions into and out of overeducated employment) for overeducated workers in the United States using NLSY79 in combination with CPS. They found that overeducation within the cohort remained substantial 12 years after the first job and that 66% of workers remained overeducated after 1 year, indicating that overeducation is quite persistent at the aggregate and individual levels.

A specific issue related to the persistence of overeducation in a labor market is whether overeducation is the shortest pathway to a job that matches the attained education level. In other words, the main concern is whether working as an overeducated worker upon labor market entry serves as a stepping stone, as predicted by Career Mobility Theory (Sicherman, 1991). Using Belgian data, Baert et al. (2013) found that overeducation at the start of a career was a trap rather than a stepping stone. They showed that monthly transition rates into non-overeducation employment fell by 51–98% for those who accepted a job for which they were overeducated compared to those who only accepted a job that matched their education level.

Based on U.K. data, Meroni and Vera-Toscano (2017) found that overeducation at the beginning of a career led to a greater likelihood of being overeducated later. They showed that overeducated workers at the beginning of a career were 13–27% less likely to have a matched job 5 years after graduation than the unemployed. Even according to sub-group analysis that distinguished between apparent overeducation (i.e., overeducated only) and genuine overeducation (i.e., mismatch in education and skill level), they obtained consistent results. In addition, a strong lock-in effect of overeducation – working but remaining overeducated persistently – also emerged in Germany (Vossemer and Schuck, 2016) and in Spain (Sánchez-Sánchez and Fernández Puente, 2021).

3.2.3 Relationship between job instability and marriage/fertility

To the best of my knowledge, studies about the relationship between underemployment and marriage/fertility are infrequent. Underemployment is one form of job instability because it carries a wage penalty and leads to lower job satisfaction and productivity and higher psychological stress. Thus, inferring how underemployment might affect marriage and childbirth is possible through a review of studies about the relationship between job instability (e.g., unemployment and part-time employment) and marriage and childbirth.

First, according to Becker's theoretical framework for marriage (1973), an increase in wage rates likely increases the incentive to marry. Based on this implication, job instability expressed as unemployment, part-time employment, and underemployment might negatively relate to marriage because job instability is highly likely to bring lower wages. Becker's analysis also implies that a rise in women's wages relative to men's wages would decrease some of the gains from marriage, assuming that the husband is the primary wage earner in a household. Thus, job instability might positively or negatively relate to marriage, depending on how the adverse impacts of a labor market disproportionately affect men and women.

Job instability negatively relates to fertility according to neoclassical fertility theory, which posits that a child is a normal good. Another theoretical approach to fertility is the opportunity cost of women's time in a fertility decision-making model (Becker, 1965; Willis, 1973). In these models, optimal time at home and at work derives from comparing the value (price) of her time and her marginal wage. Thus, other things being equal, if women's job instability increases, fertility might increase.

Assuming that an underemployment wage penalty exists, in theory, underemployment will negatively relate to marriage and childbirth for men and will positively or negatively relate to marriage and childbirth for women depending on the relative size between a reduction in wages and a reduction in opportunity cost. These theoretical implications suggest the need for empirical analysis.

Focusing on Japan, which has been experiencing an economic downturn over the past two decades, Raymo and Shibata (2017) found that unemployment and non-standard employment negatively related to marriage and fertility for men, whereas the same employment status for women led to higher levels of marriage and fertility. Based on U.S. data, Autor et al. (2019) found that marriage and childbirth were less prevalent in regions where adverse shocks to the labor market caused by global competition in manufacturing concentrated on men, while marriage and childbirth were more prevalent in regions where the adverse shocks concentrated on women. Karabchuk (2020) found that temporary employment, informal employment, and unemployment lowered fertility intentions among European youth by 16%, 26%, and 27%, respectively.

3.3 Data and Variables

3.3.1 Sample of analysis

Analysis in this study is based on data from a representative sample of eight cohorts (graduation years 2002 and 2009 with birth years 1980 and 1984) from NLSY97. One of the purposes of this study was to examine the impact on future labor market outcomes, marriage, and childbirth when a person enters a labor market for the first time underemployed. For this analysis, graduation year, history of employment status and job characteristics after graduation, and the exact dates of marriage and childbirth were necessary. NLSY97 data contain detailed information about the education, employment, marriage, and childbirth of a nationally representative sample of 8,984 men and women born between 1980 and 1984. Participants completed surveys annually from 1997 to 2011 and continued biennially afterwards.

I restricted the sample to 4-year college graduates who earned their degree between the ages of 21 and 24 to ensure (a) that they had gone straight from high school to university instead of entering college with working experience and (b) that the variables for future labor market outcomes, marriage, and childbirth after college graduation were valid. If a person born in 1980 started working after graduating high school, went back to university, and graduated in 2015, unlike those who were born in 1980 and graduated between the ages of 21 and 24, the data about labor market outcomes and history of marriage and childbirth up to 10 years after college graduation would not exist. Moreover, including these cases in the analysis might make identifying the impact of underemployment at an early stage in one's career on future labor market outcomes, marriage, and childbirth difficult due to their heterogeneity. Put differently, such non-traditional college graduates might have different characteristics from those who started college immediately after graduating high school and started working directly after graduating college.

In addition, I excluded those who had already married and had children before the year of graduation because the aim of this study was to investigate whether an initial labor market outcome persistently affected future labor market outcomes and the milestone events of marriage and childbirth.

3.3.2 Indicator of underemployment at an early stage in a labor market

Initial labor market outcome

In this study, I regarded employment outcomes in the year of and the year after graduation from a 4-year college as the first labor market outcome. I considered even the year following graduation as an initial outcome for those who did not find a job immediately after graduation – specifically, those who graduated in December, considering that they might not have had enough time to find a job in their graduation year. If one changed jobs within a year of graduation, I considered the more recent job the initial labor market outcome.

Identifying underemployment status at an early stage in a labor market

I defined the underemployed as those who had a Bachelor's degree and worked in an occupation that did not require one. To determine underemployment, the criterion for each occupation's required level of education is critical. In this study, I used the information about "required level of education" from the O*NET data of the U.S. Department of Labor to assess underemployment (Abel et al., 2014). The O*NET data is constructed through survey-based interviews of occupational experts and incumbents about which education level would be most appropriate to undertake the occupations classified by each Standard Occupational Classification (SOC) code. I defined "required level of education" in each occupation classified by SOC code as the education level that most occupational experts and incumbents answered as the education level most appropriate to perform in that occupation.

To create an index for underemployment, I first used the O*NET 14 to obtain the "required level of education" for each SOC code. As of February 2022, even though the U.S. Department of Labor provides over 30 versions of the O*NET, I used the O*NET 14 released in 2009 because NLSY97 classifies occupations based on Census 2002 classification, and the information based on the SOC 2002 code was most appropriate. Furthermore, O*NET 14 contains the largest amount of occupation information, compared to the released O*NET data from 2003 to 2009; thus, it was sufficient to cover the number of occupations of the 2009 cohort, the last cohort among the eight analyzed in this study.

Using the O*NET 14, I extracted the required level of education for each detailed occupation (i.e., at the level of 00-0000 in the SOC structure). When one SOC code required two levels of education, I assigned the higher one for that occupation. For instance, the O*NET 14 has information for occupations 11-3031.01 (Treasurers and Controllers) and 11-3031.02 (Financial Managers, Branch or Department). According to the O*NET 14, a Master's degree is most appropriate to perform the job coded 11-3031.01, and people who earn a Bachelor's degree are best suited for the job coded 11-3031.02. In this case, I decided that the required level of education for the occupation coded 11-3031 was a Master's degree. When required levels of education were three or more for a detailed occupation, I used the education level found most frequently.

To obtain the required level of education for each occupation in the sample of analysis, I merged the newly created data containing information about the required level of education with two other data: a crosswalk file between Census 2002 occupation code and SOC 2002 occupation code and the sample extracted from NLSY97. When the occupation of the sample converted to SOC 2002 code did not match one-to-one with the detailed occupation extracted from the O*NET, I first determined "one" required level of education at a broad group level (i.e., 00-000X in the SOC structure) or a minor group level (i.e., 00-0XXX in the SOC structure) and then assigned that level of education as the "required level of education" for the occupation. For example, the O*NET provides information about the required education level for occupations 11-9031, 11-9032, and 11-9033. However, it has only one occupation related to those three occupations, coded 11-9030 in the sample; in this case, I defined the required level of education for the occupation at the 11-9030 level (i.e., broad group). That is, the most frequently mentioned education level by occupational experts and incumbents as the required education level for the three occupations (i.e., 11-9031 [Bachelor's degree], 11-9032 [Master's degree], and 11-9033 [Master's degree]) is a Master's degree. Therefore, I used Master's degree as the required level of education for the occupation coded 11-9030. As in the previous example, when defining the level of education required at the upper level (i.e., a broad group or a minor group), I applied one of two methods: (a) in the case of two detailed occupation codes, I assigned the higher level of education as the required level of education for that occupation classified by a broad or minor group and (b) in the case of three or more detailed occupation codes, I assigned the most frequent education level as the required level of education.

Using this merged data, I created an index for underemployment at an early stage in a labor market by dividing the sample into two categories: (a) the underemployed who gained employment in a place where the required level of education was less than a 4-year college degree and (b) those who were not underemployed.

3.3.3 Underemployment status *n* years after graduation

To determine whether employment status *n* years after graduation was underemployment, constructing occupational history after college graduation by cohort was necessary. I used eight cohorts (i.e., graduation years 2002–2009) by birth year. For the 2002 cohort, as of 2021, occupational information from 1 to 17 years after graduation is available (i.e., 2003–2019). Similarly, occupational information from 1 to 16 years after graduation is available for the 2003 cohort, and occupational information from 1 to 10 years after graduation is available for the 2009 cohort. Thus, constructing variables for occupational history from 1 to 10 years after graduation for all eight cohorts was possible.

However, NLSY is available annually from 1997 to 2011 and biennially from 2011 to 2019. Thus, for the 2002 cohort, occupational information for the 10 years following graduation (i.e., calendar year 2012) was not available. Similarly, for the 2003 cohort, occupational information for the 9 years following graduation was not available. To deal with the difficulty of constructing a career history from 1 to 10 years after graduation, I filled in occupational information for the years not surveyed, using all other information available in NLSY97.

In the case of the 2003 cohort, for instance, I assigned job information for the 9th year (i.e., calendar year 2012) after graduation in the following three ways: (a) job in 2011 = job in 2012 if job information reported in the 2011 survey was equal to that reported in the 2013 survey (91 out of 146 cases), (b) job in 2013 = job in 2012 if job information reported in the 2011 survey was not equal to that reported in the 2013 survey and respondents reported the start year of the job in 2013 as 2012 (7 out of 146 cases), and (c) job in 2011 = job in 2012 in all other cases (48 out of 146 cases). I applied the same procedure to all other cohorts to construct occupational histories for the years without a survey. Then, by using the required level of education for each occupation extracted from the O*NET, I determined whether the employment status in the *n*th year after graduation was underemployment.

3.3.4 Other variables

Because race, college GPA, parents' educational level, year of first marriage, and years of childbearing are time invariant, I used the information reported in the survey. However, information that changes over time (e.g., industry and job type, marital status, place of residence, and weight) created a problem of omission in years without a survey.

To cope with the same problem when constructing underemployment status in the *n* years following graduation due to a missing survey (i.e., 2012, 2014, 2016, and 2018), I applied the steps I used to build variables regarding underemployment status by year. Specifically, I used the same method to create occupational history by year when creating the history of industry and job type.

For marital status as a control, in the case of the 2003 cohort, I assigned marital status for the 9th year (i.e., calendar year 2012) after graduation in the following three ways: (a) marital status in 2011 = marital status in 2012 if marital status reported in the 2011 survey was equal to that reported in the 2013 survey (126 out of 146 cases), (b) "Married" = marital status in 2012 if marital status reported in the 2011 survey was not equal to that reported in the 2013 survey and respondents reported the year of first marriage in the 2013 survey as 2012 (3 out of 146 cases), and (c) marital status in 2011 = marital status in 2012 in all other cases (17 out of 146 cases).

Regarding geographical information, I used information from the year immediately preceding for years without a survey. In other words, I considered geographical information reported in 2011 (2013, 2015, 2017) as equal to geographical information in 2012 (2014, 2016, 2018).

For weight, I first computed the average personal weight from 1 to 10 years after graduation by graduation year using the information available. I then entered the average weight as the weight for the years without a survey.

3.4 Empirical Analysis

3.4.1 Estimating the characteristics associated with starting underemployed

First, to explore which factors related underemployment at an early stage of one's career, I considered the following linear probability model:

$$UNDERINDEX_i = \beta_0 + X_{1,i}\beta_1 + X_{2,i}\beta_2 + \beta_3 * UNEMP + \varepsilon_t \tag{3.1}$$

where i represents an individual. $UNDERINDEX$ indicates whether an individual was underemployed at an early stage in a labor market immediately after graduation. X_1 represents individual backgrounds, including race, college GPA, and college major. Family backgrounds (X_2) include parents' educational attainment. To control for the possibility of being underemployed due to economic fluctuations in the labor market, I added unemployment rate in the graduation year.

In the pooled model to identify differences in the probability of being underemployed between men and women, I found that the likelihood of being underemployed in the first job was about 4.9% higher for women than for men. However, the difference was not significant.

In the sub-group analysis by gender, the results show that the probability that the first job would be underemployment related to college GPA and major. Not surprisingly, for men, when the GPA was between 3.5 and 4.0, the probability of being underemployed was 23% lower than graduates with a GPA of 2.5 or less. For women, the probability of getting a first job as underemployed decreased by 22% for a GPA between 3.0 and 3.5 and by 26% for a GPA between 3.5 and 4.0.

By major at college, for men, the probability of being underemployed was 65%, 58%, and 34% lower among those who majored in Architecture, Mathematics and Statistics, or Engineering than those who majored in Liberal Arts and Sciences and Humanities. In contrast, graduates who studied Homeland Security; Communication and Journalism; Construction Trades; Parks, Recreation, and Leisure Studies; Agriculture; or Health Professions and Related Programs were 34–62% more likely to get a job that required a lower level of education than they actually obtained than

Table 3.1: Results of linear probability model on underemployment

	Pooled	Men	Women
Gender (Base = Men)			
Women	0.049		
	(0.046)		
Race (Base = Black)			
Hispanic	-0.069	0.120	-0.165
	(0.102)	(0.163)	(0.132)
Mixed Race (Non-Hispanic)	0.030	-0.071	0.262
	(0.200)	(0.273)	(0.301)
Non-Black / Non-Hispanic	0.046	0.167	-0.006
	(0.076)	(0.121)	(0.098)
GPA (Base = GPA < 2.5)			
$2.5 \leq$ GPA < 3.0	-0.097	-0.137	-0.109
	(0.071)	(0.101)	(0.100)
$3.0 \leq$ GPA < 3.5	-0.129*	-0.045	-0.222**
	(0.068)	(0.103)	(0.092)
$3.5 \leq$ GPA ≤ 4.0	-0.204***	-0.229*	-0.261***
	(0.073)	(0.117)	(0.098)
Major (Base = Liberal Arts and Sciences or Humanities)			
Agriculture	0.467***	0.564***	0.292***
	(0.069)	(0.127)	(0.085)
Architecture	-0.218	-0.652***	0.515***
	(0.314)	(0.088)	(0.093)
Communication and Journalism	-0.111	0.462***	-0.214
	(0.156)	(0.126)	(0.157)
Computer and Information Sciences	0.038	0.062	-0.484*
	(0.194)	(0.201)	(0.272)
Education	-0.057	0.268	-0.089
	(0.135)	(0.224)	(0.152)
Engineering	-0.409***	-0.335*	-0.534***
	(0.099)	(0.193)	(0.065)
Foreign Languages, Literatures, and Linguistics	0.057		-0.003
	(0.347)		(0.320)
Biological and Biomedical Sciences	0.519***		0.582***
	(0.094)		(0.121)
Mathematics and Statistics	-0.597***	-0.580***	
	(0.094)	(0.169)	
Multi/Interdisciplinary Studies	-0.126	0.229	-0.278
	(0.244)	(0.323)	(0.224)
Parks, Recreation, and Leisure Studies	0.072	0.486***	-0.147
	(0.221)	(0.098)	(0.209)
Philosophy and Religious Studies	-0.252	-0.196	-0.545***
	(0.256)	(0.400)	(0.093)
Psychology	-0.256	0.062	-0.396**
	(0.192)	(0.316)	(0.165)

Table 3.1: (continued) Results of linear probability model on underemployment

	Pooled	Men	Women
Homeland Security	0.122	0.340***	-0.023
	(0.205)	(0.109)	(0.303)
Social Sciences	-0.204	-0.241	-0.152
	(0.165)	(0.272)	(0.224)
Construction Trades	0.460***	0.466***	
	(0.060)	(0.134)	
Visual and Performing Arts	0.083	0.185	0.017
	(0.116)	(0.245)	(0.141)
Health Professions and Related Programs	0.347***	0.618***	0.355***
	(0.101)	(0.164)	(0.113)
Business, Management, and Marketing	-0.024	-0.050	-0.004
	(0.069)	(0.095)	(0.103)
Father's education (Base = Schooling years < 12)			
$12 \leq$ Schooling years ≤ 13	0.082	0.283*	-0.073
	(0.111)	(0.170)	(0.146)
$14 \leq$ Schooling years ≤ 15	0.109	0.216	0.027
	(0.117)	(0.180)	(0.157)
Schooling years = 16	0.150	0.248	0.086
	(0.117)	(0.180)	(0.156)
Schooling years > 16	0.093	0.172	0.008
	(0.122)	(0.183)	(0.162)
Mother's education (Base = Schooling years < 12)			
$12 \leq$ Schooling years ≤ 13	0.142	0.241	0.122
	(0.107)	(0.177)	(0.131)
$14 \leq$ Schooling years ≤ 15	0.240**	0.341*	0.201
	(0.114)	(0.186)	(0.144)
Schooling years = 16	0.118	0.122	0.173
	(0.118)	(0.194)	(0.146)
Schooling years > 16	0.159	0.159	0.238
	(0.121)	(0.185)	(0.158)
Unemployment rate	0.014	-0.011	0.031
	(0.027)	(0.047)	(0.032)
Observations	579	240	339

Note. All samples were weighted when regressing. Major is classified by 2010 College Course Map (CCM). Agriculture includes "Agriculture, Agriculture Operations, and Related Services (01)" and "Natural Resources and Conservation (03)." Computer and Information Sciences includes "Communications Technologies/Technicians and Support Services (10)" and "Computer and Information Sciences and Support Services (11)." Engineering includes "Engineering (14)" and "Engineering Technologies and Engineering-Related Fields (15)." Foreign Languages, Literatures, and Linguistics includes "Foreign Languages, Literatures, and Linguistics (16)" and "English Language and Literature/Letters (23)." Parks, Recreation, and Leisure Studies includes "Personal and Culinary Services (12)" and "Parks, Recreation, and Leisure Studies (31)." Philosophy and Religious Studies includes "Philosophy and Religious Studies (38)," "Theology and Religious Vocations (39)," and "History (54)." Homeland Security includes "Homeland Security, Law Enforcement, Firefighting, and Related Protective Services (43)" and "Public Administration and Social Service Professions (44)." Construction Trades includes "Construction Trades (46)" and "Transportation and Materials Moving (49)." Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

those who studied Liberal Arts and Sciences and Humanities. For women, those who majored in Philosophy and Religious Studies, Engineering, Computer and Information Sciences, or Psychology were 40–55% less likely to be underemployed than those who majored in Liberal Arts and Sciences and Humanities. On the other hand, I found that the probability of being underemployed was about 29–58% higher when graduates majored in Agriculture, Health Professions and Related Programs, Architecture, or Biological and Biomedical Sciences. Based on the view that underemployment is a result of the difference in supply and demand in the labor market, these results (i.e., differences in the majors with a high probability of being underemployed and the majors with a low probability of being underemployed among men and women) suggest that underemployment is partially attributable to either a difference in preference for majors between men and women (supply side) or a gender preference in each occupational sector (demand side).

Parents' education attainment did not closely relate to starting work in a state of underemployment. For women, the impact of parental education level on underemployment status was not significant for all education levels of parents. While for men, when their father's education level was secondary school (i.e., schooling years between 12 and 13), the probability of being underemployed increased by 24%. When their mother was 2-year college graduate (i.e., schooling years between 14 and 15), the probability of being underemployed increased by 34%.[2]

3.4.2 Short-term effect of underemployment on marriage and childbirth

Cross-sectional analysis

To analyze the short-term effect of underemployment on marriage, I investigated how underemployment n years after graduation related to marital status in the same year. For this question, I regressed the following equation:

$$Y_i = \beta_0 + \delta * UNDERINDEX_i + X_{1,i}\beta_1 + X_{2,i}\beta_2 + X_{3,i}\beta_3 + \varepsilon_i \tag{3.2}$$

[2] I assessed degree attainment according to the number of years of education because NLSY97 only provides information about the years of education completed for parents.

where i represents an individual. A binary dependent variable (Y) indicates marital status, either married or unmarried. $UNDERINDEX$ indicates whether a person is underemployed n years after graduation. To obtain the short-term effect by n (i.e., from 1 to 10) years after graduation, I separately regressed equation (3.2) for each year after graduation. X_1 includes race as individual background. Occupational characteristics (X_2) include occupation and industry n years after graduation. X_3 indicates geographical controls, including region (Northeast, North Central, South, West), whether residing in MSA, and whether residing in an urban or rural area.

Table 3.2: Effect of underemployment on marriage and childbirth

	Marriage		Childbirth	
	Men	Women	Men	Women
1 year later	0.010	0.031		
	(0.032)	(0.040)		
2 years later	0.134**	0.008	-0.001	0.009
	(0.057)	(0.054)	(0.017)	(0.028)
3 years later	0.019	-0.004	0.036	0.007
	(0.068)	(0.060)	(0.032)	(0.038)
4 years later	0.067	0.007	-0.044	-0.012
	(0.073)	(0.066)	(0.029)	(0.035)
5 years later	0.056	-0.051	-0.076**	-0.042
	(0.084)	(0.065)	(0.037)	(0.038)
6 years later	0.052	-0.069	0.021	0.084*
	(0.083)	(0.068)	(0.050)	(0.044)
7 years later	0.077	-0.084	0.007	-0.026
	(0.088)	(0.067)	(0.041)	(0.046)
8 years later	0.166**	-0.075	0.029	0.049
	(0.083)	(0.069)	(0.078)	(0.051)
9 years later	0.150*	-0.122*	-0.124*	0.012
	(0.085)	(0.074)	(0.066)	(0.051)
10 years later	0.128	-0.106	0.078	0.081
	(0.081)	(0.071)	(0.064)	(0.055)

Note. All samples were weighted when regressing. Each coefficient comes from a separate equation for each year after graduation. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

For analysis of childbirth, I used the same equation as equation (3.2). However, in this case, the binary dependent variable (Y) indicates whether individual has a child. I additionally included marital status[3] in X_1 and job type[4] in X_2. Except for race, I used lagged variables ($n - 1$) as control variables due to the time lag between deciding to have a child and actual birth.

According to the linear probability model, I found some evidence in some years that underemployment positively related to men's marriage and negatively related to women's marriage in the short term. I also found that, apart from statistical significance, no pattern emerged for marriage by employment status with increasing age. As with marriage, I confirmed that the short-term effect of underemployment on childbirth was negligible for men and women.

Panel analysis: Fixed-effect model

As another approach, I used a fixed-effect model to determine the short-term effect of underemployment on marriage and childbirth while controlling for unobserved individual factors.

$$Y_{i,n} = \delta * UNDERINDEX_{i,n} + X_{2,i,n}\alpha_1 + X_{3,i,n}\alpha_2 + \zeta_i + \tau_t + \varepsilon_{i,n} \quad (3.3)$$

where i and n (1, ..., 10) represent an individual and the number of years since graduation, respectively. All variables used in equation (3.3) are the same as equation (3.2) except the following: (a) I dropped the time-invariant variable (i.e., race), (b) I included individual and calendar year (not the years elapsed since graduation) fixed effects. I used lagged variables ($n - 1$) for control variables to analyze the effect on childbirth.

Table 3.3 shows the effect of underemployment on marriage and childbirth in the panel analysis. I found that underemployment had no short-term effect on marriage or childbirth for men or women, similar to the results of the cross-sectional analysis.

[3] I classified marital status in the following way: (a) never married/separated/divorced/widowed, not cohabiting, (b) never married/separated/divorced/widowed, cohabiting, and (c) married.

[4] I classified job type in the following way: (a) self-employed, (b) employee with regular day shift, (c) employee with regular evening/night shift, (d) employee with irregular shift, and (e) employee with irregular schedule of hours.

Table 3.3: Effect of underemployment on marriage and childbirth: Fixed-effect model

	Marriage		Childbirth	
	Men	Women	Men	Women
Underemployment	0.037	-0.007	0.009	0.010
	(0.032)	(0.033)	(0.017)	(0.016)
Observations	2,827	3,643	3,047	3,804

Note. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

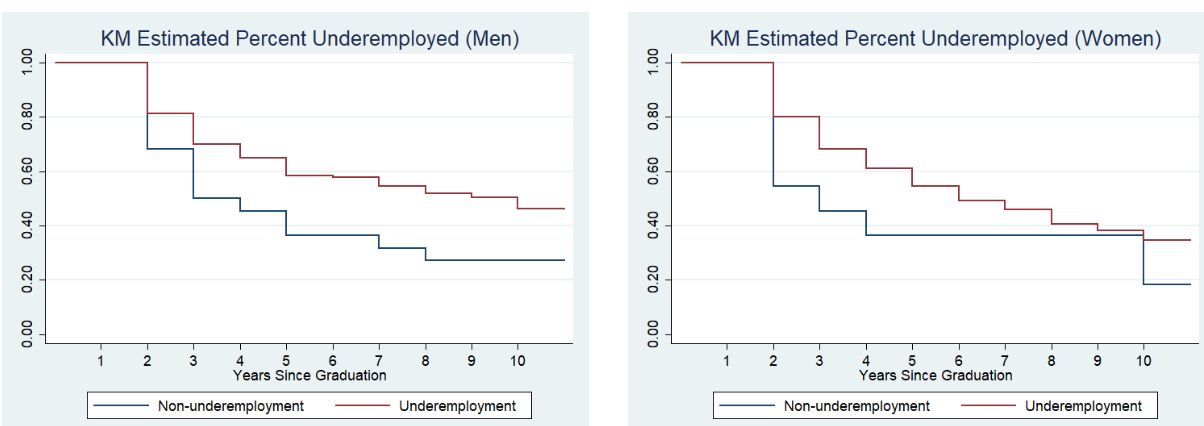
3.4.3 Long-term effect of underemployment on marriage and childbirth

3.4.3.1 Persistency of underemployment

Kaplan-Meier estimator

To examine whether initial underemployment continued to affect future labor market outcomes, I first calculated Kaplan Meier estimates. These estimates represent the probability of remaining underemployed from 1 to 10 years after graduation by employment status (i.e., underemployment and non-underemployment) in the first job. As shown in Figure 3.2, both men and women were more likely to remain underemployed in the labor market when they started working as underemployed workers immediately after graduation.

Figure 3.2: Kaplan-Meier Curve: Probability of remaining underemployed



Proportional hazard model

To analyze the persistency of underemployment in the labor market through duration analysis, I used a proportional hazard model with time-invariant covariates:

$$h(t;X) = h_0(t)exp[\beta X] \tag{3.4}$$

where $h(t;X) = \lim_{\Delta t \to 0} \frac{P(t < T \leq t + \Delta t | T > t, X)}{\Delta t}$ is the hazard conditional on the covariates (X) at time t, indicating the probability that an event (in this case, getting a matched job/moving out of underemployment) has occurred during a very small time interval Δt between t and Δt, given that the individual did not have an event until time t.[5] $h_0(t)$ is the baseline hazard. $exp[\beta X]$ is the function of observed time-invariant variables (X). Thus, this equation indicates how the hazard of event occurrence at time t individually differs proportionately based on the function of $exp[\beta X]$. I included college GPA, college major, parents' educational attainment, and unemployment at graduation year as covariates.

According to the results from the hazard model, I found that, for men, underemployed workers at the initial stage in a labor market had a lower hazard of event occurrence 10 years after graduation than initially matched workers. Numerically, underemployed male workers were 40–53% more likely to remain underemployed in the labor market. For women, I found that underemployment negatively affected future career only in the model using race and college grades and major

[5]The hazard is generally expressed as the negative natural logarithm of survival probability differentiating with respect to time t. Let $T \geq 0$ denote the duration, which is the time at which a unit leaves the initial state. t denotes a particular value of T. The survival function can be written as:

$$S(t) = P(T > t) = 1 - P(T \leq t) = 1 - F(t),$$

where $F(t) = \int_0^t f(s)ds$. $F(t)$ is a cumulative distribution function and, thus, $f(t)$ is a probability density function. Because hazard is the probability that an event has occurred during a very small time interval Δt between t and Δt:

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t < T \leq t + \Delta t | T > t)}{\Delta t} = \lim_{\Delta t \to 0} \frac{P(t < T \leq t + \Delta t) \cap P(T > t)}{P(T > t) \cdot \Delta t} = \lim_{\Delta t \to 0} \frac{P(t < T \leq t + \Delta t)}{S(t) \cdot \Delta t}$$
$$= \lim_{\Delta t \to 0} \frac{P(T \leq t + \Delta t) - P(T \leq t)}{S(t) \cdot \Delta t} = \lim_{\Delta t \to 0} \frac{F(t + \Delta t) - F(t)}{\Delta t} \cdot \frac{1}{S(t)} = \frac{dF(t)}{dt} \cdot \frac{1}{S(t)} = \frac{f(t)}{S(t)}.$$

And $h(t) = \frac{f(t)}{S(t)} = \frac{d}{dt}F(t) \cdot \frac{1}{S(t)} = \frac{d}{dt}(1 - S(t)) \cdot \frac{1}{S(t)} = -\frac{d}{dt}S(t) \cdot \frac{1}{S(t)} = -\frac{d}{dt}ln(S(t))$. Thus, we can also draw the following relationship between a survival function and a hazard function: $H(t) = -lnS(t)$, which indicates that the hazard function at time t is equal to the negative logarithm of the survival function at time t (Wooldridge, 2010, pp. 983-989).

as covariates.

Table 3.4: Possibility of moving out of underemployment

	(1)	(2)	(3)	(4)	(5)
Panel A. Men					
Underemployment	0.598**	0.592**	0.513**	0.569**	0.475***
	(0.152)	(0.145)	(0.135)	(0.160)	(0.127)
Panel B. Women					
Underemployment	0.643	0.647	0.415**	0.567	0.565
	(0.209)	(0.202)	(0.183)	(0.334)	(0.358)
Race		Yes	Yes	Yes	Yes
GPA & Major			Yes	Yes	Yes
Parents' education				Yes	Yes
Unemployment					Yes

Note. The figures in the table represent an estimated hazard ratio. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

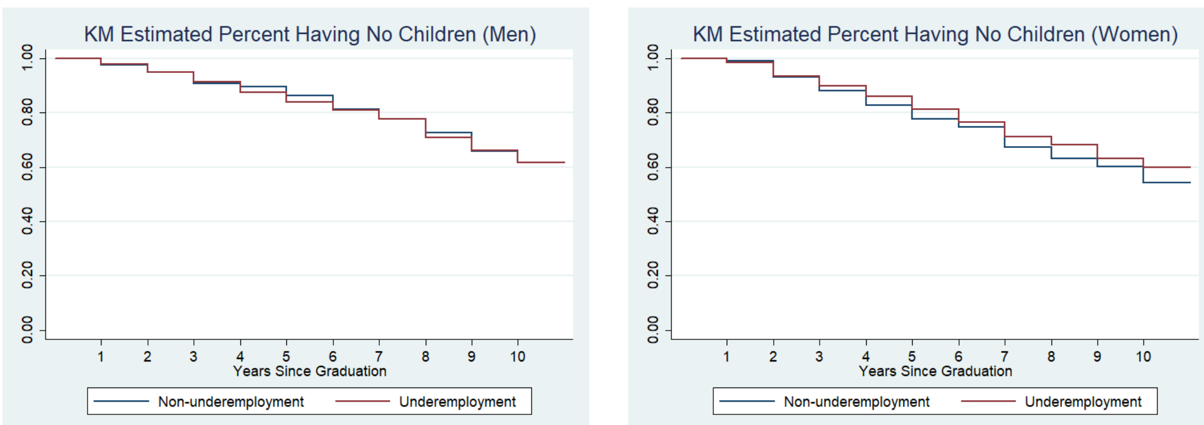
3.4.3.2 Long-term effect on marriage and childbirth

Kaplan-Meier estimator

Panel A in Figure 3.3 shows the probability of remaining unmarried after 10 years since graduation. Both men and women were less likely to marry after graduation when they started working as underemployed workers in their first job. Panel B in Figure 3.3 displays the probability of not having children by employment status in the initial job. For men, little difference emerged in the probability of not having children between the underemployed and the employed working at a well-matched job. Women were less likely to have a first child within 10 years of graduation when they started working as underemployed workers in their first job than women who were initially not underemployed.

Figure 3.3: Kaplan-Meier Curve

(a) *Panel A. Probability of remaining unmarried*



(b) *Panel B. Probability of having no children*

Proportional hazard model

To estimate the long-term effect of underemployment on marriage and childbirth, I used the same equation as equation (3.4), except that the event in the analysis on marriage is the first marriage and the event in the analysis on childbirth is the birth of the first child.

Panel A in Table 3.5 illustrates the long-term effect of underemployment on marriage. I found that underemployment at an early stage in the labor market did not have a significant effect on marriage for men or women, even though the hazard ratios were estimated to be less than one in all models. As shown in Table 3.5, underemployment in the first job was not a proper predictor of having a child for men. However, I found that underemployed women were about 27% less likely to have a first child within 10 years of graduation compared to women who were initially not underemployed.

Table 3.5: Long-term effect of underemployment

	(1)	(2)	(3)	(4)	(5)
Panel A. Possibility of getting married					
Men					
Underemployment	0.940	0.928	0.999	0.957	0.956
	(0.125)	(0.124)	(0.177)	(0.185)	(0.185)
Women					
Underemployment	0.909	0.936	0.841	0.897	0.878
	(0.105)	(0.109)	(0.125)	(0.141)	(0.139)
Panel B. Probability of having a first child					
Men					
Underemployment	1.008	1.011	0.930	0.820	0.828
	(0.156)	(0.156)	(0.193)	(0.186)	(0.190)
Women					
Underemployment	0.851	0.861	0.719**	0.731*	0.727*
	(0.110)	(0.111)	(0.118)	(0.127)	(0.127)
Race		Yes	Yes	Yes	Yes
GPA & Major			Yes	Yes	Yes
Parents' education				Yes	Yes
Unemployment					Yes

Note. The figures in the table represent an estimated hazard ratio. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

To sum up, I did not find that working in a place that required a level of education lower than the level of education the worker attained prevented marriage and childbirth in the short term. Because marriage and childbirth essentially relate to income, the result that underemployment did not have a significant effect on marriage and childbirth could be the result of one or both of the following: (a) that the wage penalty of underemployment was not significant enough to affect marriage and childbirth or (b) that the underemployment phenomenon resolved itself in the short term. Based on this interpretation, the results are partially consistent with the view of Human Capital Theory, which considers underemployment a temporary phenomenon simply caused by a mismatch that occurs in the process of looking for a job (Becker, 1964).

In the analysis using the hazard model, I found that both men and women were continually in an adverse employment state in the future labor market when they accepted a non-matched job between their actual education level and the education level required by the job. These findings suggest that underemployment is not a temporary or negligible phenomenon as described in Human Capital Theory. These results are consistent with previous findings that underemployment is a trap rather than a stepping stone in the labor market (Baert et al., 2013; Meroni and Vera-Toscano, 2017).

As in the short-term effect analysis, I found no evidence that underemployment related to marital status in the long run in the hazard model. However, at least for women, I confirmed that underemployment negatively related to childbirth. One possible explanation for this result is that the effect of lowering income due to underemployment was greater than the effect of reducing the opportunity cost of having children while underemployed.

3.5 Robustness Check

In this chapter, I defined the required education level by occupation as the most frequently observed education level for each occupation (Clark et al., 2017; Mohnen, 2017). To assign the most frequently observed education level for each occupation, I used the *OCC*2010 (occupation classification code based on 2010) and *EDUCD* (detailed education attainment) variables in ACS. I restricted the sample for assigning the required level of education to only employed workers ages 21–30 surveyed from 2002 to 2009.[6] To construct an indicator of whether an individual was underemployed, I matched occupation in NLSY97 with occupation in the newly created dataset containing information about the most frequently observed education level by occupation based on ACS. When matching, I used a crosswalk file between Census Occupation code 2002 and 2010 because NLSY97 classifies occupation based on the 2002 Census classification. With this information, I classified a worker as underemployed when the most frequently observed education level

[6]Because I used a sample with graduation years from 2002 to 2009 in NLSY97, I restricted the years to 2002 to 2009 of the ACS data in preparing the criterion for assigning the required education level to determine whether people were underemployed right after graduation.

in the worker's occupation was less than a Bachelor's degree.

3.5.1 Estimating characteristics associated with starting underemployed

Regardless of the approach used to determine underemployment, I found that college major closely related to the probability of being underemployed.[7] The results show that, for both men and women, the majors with a high probability of being underemployed and the majors with a low probability of being underemployed were almost identical, even though the magnitude of the impact was slightly different.[8]

However, using a statistical approach, I found that the probability of being underemployed closely related to race and father's education level, whereas the probability did not relate to college GPA for men. Specifically, Hispanics were 29% more likely to be underemployed and non-Blacks and non-Hispanics were 26% more likely to be underemployed than Blacks. Contrary to expectation, those with fathers with a high school diploma or higher were more likely to be underemployed than those with fathers who did not graduate from high school. These results might be due to limiting the sample to only 4-year college graduates.

For women, the results are consistent with the results in Section 3.4.1 in that the higher college GPA, the lower the probability of being underemployed. However, unlike the previous results, parents' educational backgrounds related to becoming underemployed in the first job, even in the case of women.

[7]See Appendix, Table 3.B1 for details.

[8]See Appendix, Table 3.B2 for details. Note that Health Professions and Related Programs, unlike other majors, were negatively or positively related to the probability of being underemployed according to the measurement method. This result is partially due to the measurement error caused by defining occupation at a minor or broad level, even though occupations related to health are diverse and each occupation requires a different education level. Indeed, the pros and cons of each criterion for determining whether a worker is underemployed and the gap in the incidence of underemployment by each criterion are also important topics in the analysis of underemployment. However, I did not cover this issue in more detail because the topic is beyond the scope of the current study.

3.5.2 Short-term effect of underemployment on marriage and childbirth

Similar to the results in Section 3.4.2, I confirmed that underemployment generally did not relate to marriage and childbirth in the short term in both cross-sectional and panel analyses. However, I found only minimal evidence that underemployment negatively related to marriage in some years for women.

3.5.3 Long-term effect of underemployment on marriage and childbirth

Although some differences in the estimates emerged, the pattern of the Kaplan-Meier curve according to employment status was similar to the curve resulting from the objective approach to assessing underemployment. When people worked in an underemployment state at their first job, the probability of remaining underemployed for 10 years after graduation was significantly higher for both men and women than for those whose first job matched their education level. In the analysis of marriage, the probability of remaining single for underemployed workers was slightly higher than for non-underemployed workers, but the difference was minor. In the case of childbirth, I found that the probability of having a child among underemployed men was slightly higher than the probability among non-underemployed men. For women, the probability of having a child among underemployed workers was slightly lower than the probability among non-underemployed workers, but the difference was insignificant.

In the hazard model analysis, the effect of underemployment was continuous in the labor market among underemployed men in their first job. The probability of moving to a matched job decreased by 48% compared to those who were not initially underemployed, which falls within the range of the effects estimated (i.e., 40–53%) in Section 3.4.3 using an objective approach. I found that accepting a job in which the worker was underemployed in the first job did not prevent marriage for both men and women in the long term, regardless of the approach for determining underemployment status. In addition, for men, underemployment did not relate to childbirth, same as the previous result in Section 3.4.3. The negative impact of underemployment on childbirth among women found in Section 3.4.3 disappeared in the analysis using a statistical approach.

3.6 Discussion

According to the Human Capital Theory, an increase in the number of years of education directly translates to an increase in wages, a trend connected to the popular belief that education is the great equalizer. However, the results of this study – the likelihood of being underemployed in the first job related not only to personal choice attributes (i.e., college GPA and major) but also to innate attributes (i.e., race and family background) – question that belief. This doubt intensifies considering that family background can affect even the choice of major (Santiago Vela, 2021). The results of the current study revealed that the direction of the impacts of race and parents' educational level on the probability of being underemployed was somewhat inconsistent with a common assumption that individuals from less privileged classes are more likely to be underemployed. However, the fact that family background itself can influence the probability of being underemployed suggests the need to explore the role of education in the context of social stratification and inequality.

I also found one piece of evidence of a negative relationship between underemployment and childbirth. This finding suggests that unfavorable status in the labor market might eventually lead to differences in the opportunity to have children. Whether the gap in the probability of having a first child depending on whether women were initially underemployed might be a form of inequality is worth discussing, given the assumption that underemployment status does not influence preference for having children despite heterogeneity in the choice to have children across individuals.

3.7 Conclusion

The phenomenon of underemployment has been prevalent in developed countries for some time, but now the trend is emerging in other developing countries. Thus, many researchers have devoted themselves to this topic. However, they have focused on the size of incidence of underemployment, the relationship between underemployment and wages (or job/life satisfaction, productivity in the workplace), and whether underemployment is a better option than unemployment. In the current study, I analyzed the short- and long-term effects of underemployment on marriage and childbirth by regarding underemployment as another form of job instability.

First, in the preliminary analysis, I found that being underemployed closely related to college grades and major. In the cross-sectional and panel analyses, I did not find any evidence that underemployment negatively related to marriage and childbirth in the short term. I also found the following results in the hazard model analysis with time-invariant covariates: (a) men and women who settled down in a non-matched job between the actual education level they attained and the one required by the job were more likely to remain underemployed in the future labor market and (b) underemployed women were less likely to have a child within 10 years of graduating from college. Finally, through a robustness check, I found that the negative impact on women's future career and childbirth were not significant. However, the results show that, for men, underemployment upon entering the labor market persistently made the underemployed remain underemployed in the future, regardless of the method for classifying underemployment status.

I acknowledge the limitations of this study. First, the number of samples used in analyses was quite small because I restricted the sample to only 4-year college graduates, raising concerns about the reliability of the results. The second is the possibility of measurement error in measuring underemployment. Another possible measurement error comes from the process of constructing the history of occupation, marriage, and childbirth due to the biennial surveys provided by NLSY97 since 2011. A measurement error might have occurred while filling in the information for the years not surveyed, even though I tried to use all available information. Thus, further study on this topic using a larger dataset would be worthwhile.

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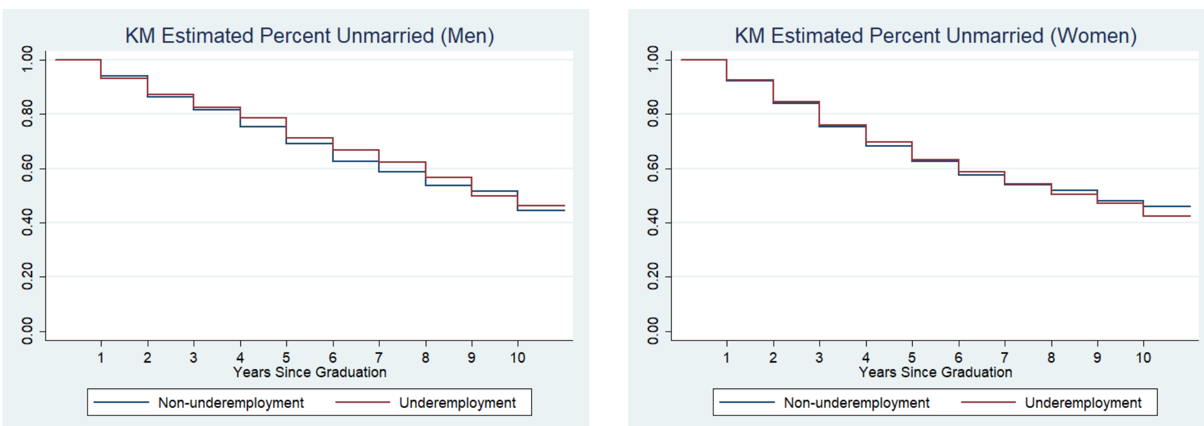
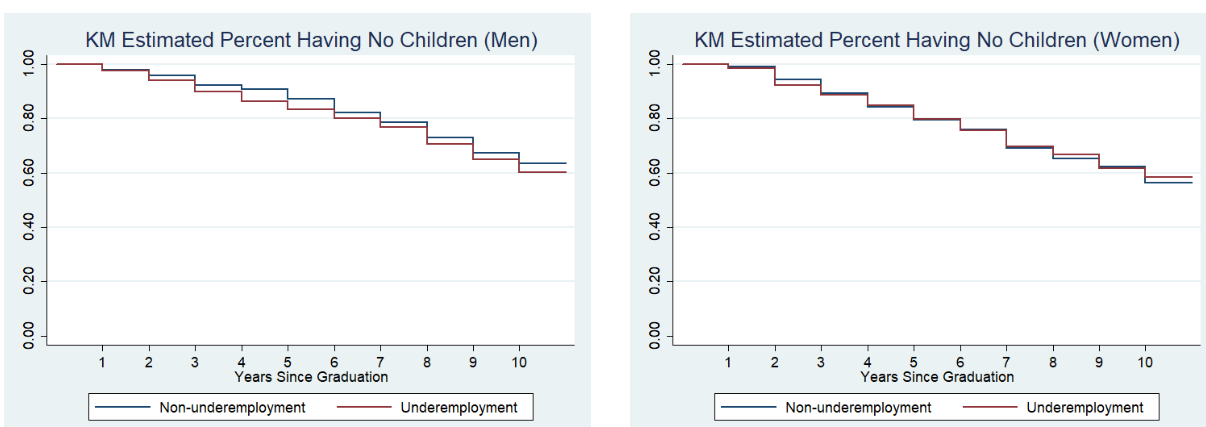
Appendix A. Figures

Figure 3.A1: Kaplan-Meier Curve: using a statistical approach

(a) *Panel A. Probability of remaining underemployed*



(b) *Panel B. Probability of remaining unmarried*



(c) *Panel C. Probability of having no children*

Appendix B. Tables

Table 3.B1: Descriptive statistics: using an objective approach

		Men		Women	
Underemployment		Under-employment	Non-under employment	Under-employment	Non-under employment
		122 (0.51)	118 (0.49)	188 (0.55)	151 (0.45)
Graduation year					
	2002	8 (0.67)	4 (0.33)	7 (0.44)	9 (0.56)
	2003	13 (0.52)	12 (0.48)	28 (0.60)	19 (0.40)
	2004	14 (0.47)	16 (0.53)	35 (0.56)	27 (0.44)
	2005	29 (0.55)	24 (0.45)	37 (0.61)	24 (0.39)
	2006	30 (0.56)	24 (0.44)	34 (0.43)	45 (0.57)
	2007	14 (0.36)	25 (0.64)	32 (0.63)	19 (0.37)
	2008	13 (0.54)	11 (0.46)	12 (0.67)	6 (0.33)
	2009	1 (0.33)	2 (0.67)	3 (0.60)	2 (0.40)
Race					
	Black	13 (0.46)	15 (0.54)	21 (0.60)	14 (0.40)
	Hispanic	11 (0.46)	13 (0.54)	18 (0.43)	24 (0.57)
	Mixed Race (Non-Hispanic)	2 (0.50)	2 (0.50)	3 (0.75)	1 (0.25)
	Non-Black / Non-Hispanic	96 (0.52)	88 (0.48)	146 (0.57)	112 (0.43)
GPA					
	GPA < 2.5	25 (0.56)	20 (0.44)	28 (0.68)	13 (0.32)
	$2.5 \leq$ GPA < 3.0	40 (0.53)	36 (0.47)	49 (0.60)	33 (0.40)
	$3.0 \leq$ GPA < 3.5	43 (0.55)	35 (0.45)	63 (0.51)	61 (0.49)
	$3.5 \leq$ GPA ≤ 4.0	14 (0.34)	27 (0.66)	48 (0.52)	44 (0.48)
Major					
	Agriculture	1 (1.00)	0 (0.00)	2 (1.00)	0 (0.00)
	Architecture	0 (0.00)	2 (1.00)	1 (1.00)	0 (0.00)
	Communication and Journalism	1 (1.00)	0 (0.00)	5 (0.45)	6 (0.55)
	Computer and Information Sciences	4 (0.57)	3 (0.43)	1 (0.50)	1 (0.50)
	Education	2 (0.50)	2 (0.50)	6 (0.43)	8 (0.57)
	Engineering	2 (0.29)	5 (0.71)	0 (0.00)	6 (1.00)
	Foreign Languages, Literatures, and Linguistics	0 (.)	0 (.)	2 (0.67)	1 (0.33)
	Liberal Arts and Sciences, and Humanities	79 (0.51)	77 (0.49)	129 (0.58)	95 (0.42)
	Biological and Biomedical Sciences	0 (.)	0 (.)	2 (1.00)	0 (0.00)

Table 3.B1: (continued) Descriptive statistics: using an objective approach

	Men		Women	
Mathematics and Statistics	0 (0.00)	2 (1.00)	0 (.)	0 (.)
Multi/Interdisciplinary Studies	1 (0.50)	1 (0.50)	1 (0.33)	2 (0.67)
Parks, Recreation and Leisure Studies	2 (1.00)	0 (0.00)	1 (0.50)	1 (0.50)
Philosophy and Religious Studies	1 (0.50)	1 (0.50)	0 (0.00)	1 (1.00)
Psychology	1 (0.50)	1 (0.50)	1 (0.20)	4 (0.80)
Homeland Security	2 (1.00)	0 (0.00)	2 (0.40)	3 (0.60)
Social Sciences	1 (0.25)	3 (0.75)	2 (0.40)	3 (0.60)
Construction Trades.	2 (1.00)	0 (0.00)	0 (.)	0 (.)
Visual and Performing Arts.	3 (0.60)	2 (0.40)	8 (0.62)	5 (0.38)
Health Professions and Related Programs	1 (1.00)	0 (0.00)	8 (0.89)	1 (0.11)
Business, Management, and Marketing	19 (0.50)	19 (0.50)	17 (0.55)	14 (0.45)
Father's education				
Schooling years $<$ 12	3 (0.21)	11 (0.79)	11 (0.46)	13 (0.54)
12 $\leq$ Schooling years $\leq$ 13	44 (0.59)	30 (0.41)	61 (0.50)	62 (0.50)
14 $\leq$ Schooling years $\leq$ 15	26 (0.57)	20 (0.43)	38 (0.63)	22 (0.37)
Schooling years = 16	27 (0.47)	30 (0.53)	45 (0.62)	28 (0.38)
Schooling years $>$ 16	22 (0.45)	27 (0.55)	33 (0.56)	26 (0.44)
Mother's education				
schooling years $<$ 12	3 (0.30)	7 (0.70)	12 (0.43)	16 (0.57)
12 $\leq$ Schooling years $\leq$ 13	47 (0.53)	41 (0.47)	56 (0.49)	58 (0.51)
14 $\leq$ Schooling years $\leq$ 15	29 (0.63)	17 (0.37)	50 (0.62)	31 (0.38)
Schooling years = 16	23 (0.43)	30 (0.57)	46 (0.61)	30 (0.39)
Schooling years $>$ 16	20 (0.47)	23 (0.53)	24 (0.60)	16 (0.40)
Average years remaining underemployed after 1 year since graduation	4.2 (2.6)	3.4 (1.9)	4.5 (2.5)	4.1 (3.4)
Average years remaining single since graduation	5.4 (2.9)	5.1 (2.9)	4.8 (2.8)	4.3 (2.6)
Average years remaining childless since graduation	6.1 (2.8)	6.3 (2.8)	5.7 (2.7)	5.8 (2.7)

Note. Except for the three lines from the bottom, the figures in parentheses represent the share by employment status (i.e., underemployment and non-underemployment) for each category. The figures in parentheses in the three lines from the bottom represent the standard deviation.

Table 3.B2: Results of linear probability model on underemployment: using a statistical approach

	Pooled	Men	Women
Gender (Base = Men)			
Women	-0.024		
	(0.046)		
Race (Base = Black)			
Hispanic	0.071	0.291*	-0.129
	(0.102)	(0.157)	(0.132)
Mixed Race (Non-Hispanic)	0.080	0.033	0.271
	(0.208)	(0.282)	(0.315)
Non-Black / Non-Hispanic	0.085	0.256**	-0.062
	(0.078)	(0.118)	(0.097)
GPA (Base = GPA < 2.5)			
$2.5 \leq$ GPA < 3.0	-0.091	-0.095	-0.110
	(0.071)	(0.098)	(0.097)
$3.0 \leq$ GPA < 3.5	-0.142**	-0.050	-0.226**
	(0.068)	(0.102)	(0.091)
$3.5 \leq$ GPA ≤ 4.0	-0.191***	-0.111	-0.277***
	(0.073)	(0.115)	(0.096)
Major (Base = Liberal Arts and Sciences or Humanities)			
Agriculture	0.443***	0.337***	0.287***
	(0.057)	(0.123)	(0.089)
Architecture	0.038	-0.268	0.561***
	(0.335)	(0.396)	(0.093)
Communication and Journalism	-0.239*	0.326***	-0.382***
	(0.142)	(0.119)	(0.130)
Computer and Information Sciences	0.041	0.114	-0.468*
	(0.188)	(0.184)	(0.258)
Education	-0.003	-0.220	0.076
	(0.134)	(0.323)	(0.149)
Engineering	-0.447***	-0.447**	-0.516***
	(0.096)	(0.195)	(0.069)
Foreign Languages, Literatures, and Linguistics	-0.302		-0.365*
	(0.247)		(0.198)
Biological and Biomedical Sciences	0.539***		0.635***
	(0.091)		(0.125)
Mathematics and Statistics	-0.664***	-0.686***	
	(0.080)	(0.137)	
Multi/Interdisciplinary Studies	-0.145	0.145	-0.243
	(0.233)	(0.354)	(0.213)
Parks, Recreation, and Leisure Studies	0.059	0.407***	-0.130
	(0.205)	(0.091)	(0.206)
Philosophy and Religious Studies	-0.270	-0.227	-0.465***
	(0.242)	(0.384)	(0.100)
Psychology	-0.274	0.042	-0.382**
	(0.187)	(0.281)	(0.155)

Table 3.B2: (continued) Results of linear probability model on underemployment: using a statistical approach

	Pooled	Men	Women
Homeland Security	0.085	0.296***	-0.027
	(0.199)	(0.110)	(0.307)
Social Sciences	-0.222	-0.285	-0.139
	(0.167)	(0.280)	(0.235)
Construction Trades	0.389***	0.386***	
	(0.069)	(0.116)	
Visual and Performing Arts	0.011	-0.093	0.048
	(0.119)	(0.233)	(0.142)
Health Professions and Related Programs	-0.374***	-0.401**	-0.301**
	(0.133)	(0.162)	(0.142)
Business, Management, and Marketing	-0.088	-0.090	-0.074
	(0.068)	(0.097)	(0.101)
Father's education (Base = Schooling years $<$ 12)			
$12 \leq$ Schooling years ≤ 13	0.062	0.456***	-0.192*
	(0.105)	(0.154)	(0.109)
$14 \leq$ Schooling years ≤ 15	0.085	0.468***	-0.143
	(0.113)	(0.161)	(0.126)
Schooling years = 16	0.123	0.433***	-0.039
	(0.112)	(0.163)	(0.120)
Schooling years $>$ 16	0.075	0.371**	-0.124
	(0.117)	(0.167)	(0.126)
Mother's education (Base = Schooling years $<$ 12)			
$12 \leq$ Schooling years ≤ 13	0.124	0.073	0.156
	(0.104)	(0.195)	(0.124)
$14 \leq$ Schooling years ≤ 15	0.227**	0.175	0.229*
	(0.110)	(0.197)	(0.133)
Schooling years = 16	0.102	-0.070	0.225
	(0.115)	(0.208)	(0.137)
Schooling years $>$ 16	0.176	0.011	0.328**
	(0.119)	(0.201)	(0.149)
Unemployment rate	0.012	0.005	0.023
	(0.028)	(0.049)	(0.034)
Observations	579	240	339

Note. I used a statistical approach to determine underemployment status. All samples were weighted when regressing. Major is classified by 2010 College Course Map (CCM). Agriculture includes "Agriculture, Agriculture Operations, and Related Services (01)" and "Natural Resources and Conservation (03)." Computer and Information Sciences includes "Communications Technologies/Technicians and Support Services (10)" and "Computer and Information Sciences and Support Services (11)." Engineering includes "Engineering (14)" and "Engineering Technologies and Engineering-Related Fields (15)." Foreign Languages, Literatures, and Linguistics includes "Foreign Languages, Literatures, and Linguistics (16)" and "English Language and Literature/Letters (23)." Parks, Recreation, and Leisure Studies includes "Personal and Culinary Services (12)" and "Parks, Recreation, and Leisure Studies (31)." Philosophy and Religious Studies includes "Philosophy and Religious Studies (38)," "Theology and Religious Vocations (39)," and "History (54)." Homeland Security includes "Homeland Security, Law Enforcement, Firefighting, and Related Protective Services (43)" and "Public Administration and Social Service Professions (44)." Construction Trades includes "Construction Trades (46)" and "Transportation and Materials Moving (49)." Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.B3: Ranking of majors according to probability of first job that matches attained and required level of education

Panel A. Using an objective approach

Men		Women	
Architecture	-0.652***	Philosophy and Religious Studies	-0.545***
Mathematics and Statistics	-0.580***	Engineering	-0.534***
Engineering	-0.335*	Computer and Information Sciences	-0.484*
Social Sciences	-0.241	Psychology	-0.396**
Philosophy and Religious Studies	-0.196	Multi/Interdisciplinary Studies	-0.278
Business, Management, and Marketing	-0.050	Communication and Journalism	-0.214
Computer and Information Sciences	0.062	Social Sciences	-0.152
Psychology	0.062	Parks, Recreation, and Leisure Studies	-0.147
Visual and Performing Arts.	0.185	Education	-0.089
Multi/Interdisciplinary Studies	0.229	Homeland Security	-0.023
Education	0.268	Business, Management, and Marketing	-0.004
Homeland Security	0.340***	Foreign Languages, Literatures, and Linguistics	-0.003
Communication and Journalism	0.462***	Visual and Performing Arts.	0.017
Construction Trades.	0.466***	Agriculture	0.292***
Parks, Recreation, and Leisure Studies	0.486***	Health Professions and Related Programs	0.355***
Agriculture	0.564***	Architecture	0.515***
Health Professions and Related Programs	0.618***	Biological and Biomedical Sciences	0.582***

Note. The figures in the table come from Table 3.1. Baseline is Liberal Arts and Sciences or Humanities. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.B3: (continued) Ranking of majors according to probability of first job that matches attained and required level of education

Panel B. Using a statistical approach

Men		Women	
Mathematics and Statistics	-0.686***	Engineering	-0.516***
Engineering	-0.447**	Computer and Information Sciences	-0.468*
Health Professions and Related Programs	-0.401**	Philosophy and Religious Studies	-0.465***
Social Sciences	-0.285	Communication and Journalism	-0.382***
Architecture	-0.268	Psychology	-0.382**
Philosophy and Religious Studies	-0.227	Foreign Languages, Literatures, and Linguistics	-0.365*
Education	-0.220	Health Professions and Related Programs	-0.301**
Visual and Performing Arts	-0.093	Multi/Interdisciplinary Studies	-0.243
Business, Management, and Marketing	-0.090	Social Sciences	-0.139
Psychology	0.042	Parks, Recreation, and Leisure Studies	-0.130
Computer and Information Sciences	0.114	Business, Management, and Marketing	-0.074
Multi/Interdisciplinary Studies	0.145	Homeland Security	-0.027
Homeland Security	0.296***	Visual and Performing Arts	0.048
Communication and Journalism	0.326***	Education	0.076
Agriculture	0.337***	Agriculture	0.287***
Construction Trades	0.386***	Architecture	0.561***
Parks, Recreation, and Leisure Studies	0.407***	Biological and Biomedical Sciences	0.635***

Note. The figures in the table come from Table 3.B1. Baseline is Liberal Arts and Sciences or Humanities. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.B4: Effect of underemployment on marriage and childbirth: using a statistical approach

	Marriage		Childbirth	
	Men	Women	Men	Women
1 year later	0.037	0.053		
	(0.036)	(0.045)		
2 years later	0.050	-0.009	0.034	0.040
	(0.056)	(0.056)	(0.027)	(0.033)
3 years later	-0.082	0.053	-0.001	-0.010
	(0.053)	(0.070)	(0.040)	(0.037)
4 years later	-0.034	-0.041	0.025	0.029
	(0.065)	(0.068)	(0.033)	(0.036)
5 years later	0.051	-0.083	0.035	-0.005
	(0.076)	(0.069)	(0.039)	(0.046)
6 years later	-0.078	-0.126*	-0.013	0.077
	(0.083)	(0.075)	(0.046)	(0.055)
7 years later	0.005	-0.047	0.105**	-0.075
	(0.084)	(0.079)	(0.050)	(0.055)
8 years later	0.067	-0.079	-0.044	-0.019
	(0.085)	(0.085)	(0.061)	(0.042)
9 years later	0.053	-0.190**	0.052	-0.006
	(0.085)	(0.091)	(0.059)	(0.061)
10 years later	0.057	-0.086	0.055	0.128**
	(0.082)	(0.094)	(0.060)	(0.061)

Note. I used a statistical approach to determine underemployment status. All samples were weighted when regressing. Each coefficient comes from a separate equation for each year after graduation. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.B5: Effect of underemployment on marriage and childbirth: Fixed-effect model with a statistical approach

	Marriage		Childbirth	
	Men	Women	Men	Women
Underemployment	0.008	-0.006	-0.003	0.006
	(0.033)	(0.033)	(0.017)	(0.019)
Observations	2,855	3,652	3,070	3,813

Note. I used a statistical approach to determine underemployment status. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 3.B6: Long-term effect of underemployment: Hazard model with a statistical approach

	(1)	(2)	(3)	(4)	(5)
Panel A. Possibility of moving out of underemployment					
Men					
Underemployment	0.768	0.750	0.515**	0.569	0.520*
	(0.239)	(0.237)	(0.173)	(0.225)	(0.181)
Women					
Underemployment	0.647	0.668	0.746	1.131	1.306
	(0.207)	(0.217)	(0.328)	(0.649)	(0.816)
Panel B. Possibility of getting married					
Men					
Underemployment	0.948	0.943	1.025	0.947	0.947
	(0.125)	(0.125)	(0.175)	(0.181)	(0.181)
Women					
Underemployment	1.062	1.102	1.010	1.143	1.126
	(0.123)	(0.127)	(0.150)	(0.178)	(0.177)
Panel C. Probability of having a first child					
Men					
Underemployment	1.115	1.132	0.964	0.893	0.902
	(0.173)	(0.176)	(0.191)	(0.193)	(0.196)
Women					
Underemployment	0.953	0.962	0.820	0.883	0.880
	(0.123)	(0.124)	(0.140)	(0.164)	(0.164)
Race		Yes	Yes	Yes	Yes
GPA & Major			Yes	Yes	Yes
Parents' education				Yes	Yes
Unemployment					Yes

Note. I used a statistical approach to determine underemployment status. The figures in the table represent an estimated hazard ratio. Robust standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Appendix C. Supplemental Analysis

I supplementally examined the effect of underemployment on marital status using propensity score matching:

$$Y_i = \beta_0 + \delta * UNDERINDEX_i + X_{1,i}\beta_1 + X_{2,i}\beta_2 + X_{3,i}\beta_3 + \varepsilon_i \tag{3.5}$$

where i represents an individual. A binary dependent variable (Y) indicates marital status, either married or unmarried. $UNDERINDEX$ indicates whether a person was underemployed n years after graduation. X_1 represents individual background, including race, graduation year, college GPA, and college major. Occupational characteristics, X_2, include occupation and industry n years after graduation. X_3 indicates geographical controls, including region (Northeast, North Central, South, West), whether residing in MSA, and whether residing in an urban or rural area.

For analysis of childbirth, I used the same equation as equation (3.5). However, in this case, the binary dependent variable (Y) indicates whether an individual has a child. I additionally included marital status in X_1 and job type in X_2. Except for time-invariant variables such as race and the year of graduation, I used lagged variables ($n - 1$) as control variables due to the time lag between deciding to have a child and actual birth. I excluded the effect of underemployment on childbirth for men because of sample attrition while matching the propensity score to be underemployed n years after graduation.

Table 3.C1: Effect of underemployment on marriage and childbirth: using Propensity Score Matching with an objective approach

	Marriage		Childbirth
	Men	Women	Women
1 year later	-0.125	0.133	
	(0.266)	(0.143)	
2 years later	0.208	0.120	0.300
	(0.184)	(0.115)	(0.254)
3 years later	0.051	0.070	-0.091
	(0.145)	(0.099)	(0.316)
4 years later	0.000	-0.033	0.133
	(0.143)	(0.096)	(0.188)
5 years later	0.088	-0.028	-0.353
	(0.121)	(0.092)	(0.204)
6 years later	0.090	-0.092	0.067
	(0.115)	(0.092)	(0.155)
7 years later	0.015	-0.209	0.000
	(0.118)	(0.088)	(0.172)
8 years later	0.206	-0.145	0.053
	(0.118)	(0.096)	(0.181)
9 years later	0.146	-0.023	-0.167
	(0.105)	(0.095)	(0.190)
10 years later	-0.012	-0.114	0.100
	(0.109)	(0.112)	(0.158)

Note. I used an objective approach to determine underemployment status. I excluded analysis of childbirth for men because of sample attrition while matching the propensity score to be underemployed n years after graduation. Each coefficient comes from a separate equation for each year after graduation. Standard errors are in parentheses.

Table 3.C2: Effect of underemployment on marriage and childbirth: using Propensity Score Matching with a statistical approach

	Marriage		Childbirth
	Men	Women	Women
1 year later	0.250	0.133	
	(0.285)	(0.141)	
2 years later	0.115	0.100	0.273
	(0.162)	(0.115)	(0.259)
3 years later	0.049	0.099	-0.091
	(0.137)	(0.096)	(0.255)
4 years later	0.023	-0.044	0.000
	(0.145)	(0.089)	(0.208)
5 years later	0.119	0.000	-0.050
	(0.113)	(0.088)	(0.190)
6 years later	0.100	0.017	0.107
	(0.119)	(0.086)	(0.123)
7 years later	0.014	-0.023	0.029
	(0.120)	(0.085)	(0.129)
8 years later	0.153	-0.092	-0.050
	(0.111)	(0.095)	(0.185)
9 years later	0.031	-0.077	0.000
	(0.102)	(0.091)	(0.188)
10 years later	0.069	-0.100	0.233
	(0.100)	(0.107)	(0.136)

Note. I used a statistical approach to determine underemployment status. I excluded analysis of childbirth for men because of sample attrition while matching the propensity score to be underemployed n years after graduation. Each coefficient comes from a separate equation for each year after graduation. Standard errors are in parentheses.